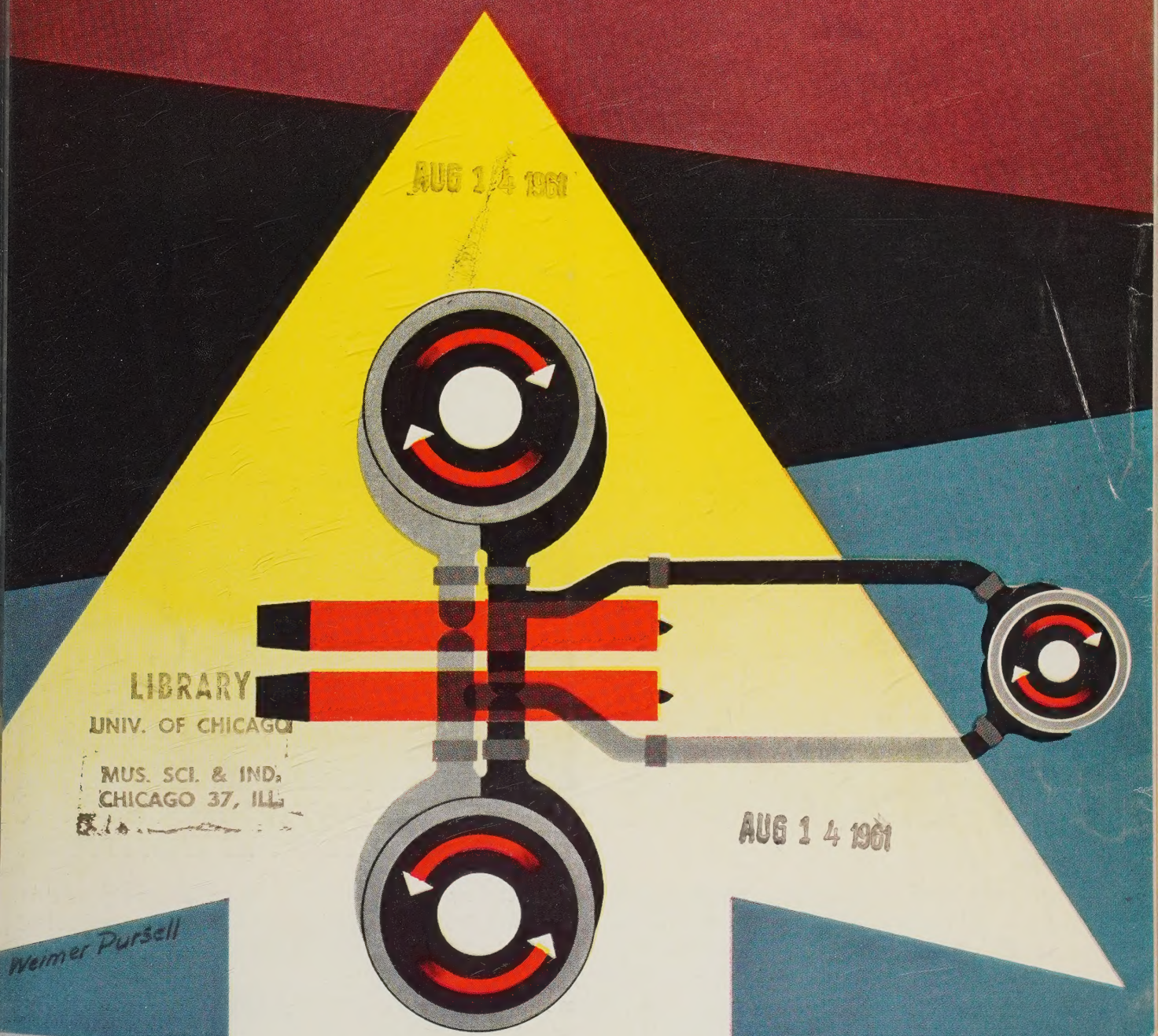
Space/Aeronautics

THE MAGAZINE OF AEROSPACE TECHNOLOGIES

AUGUST 1961



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Werner Pursell

Lift-Fan Installation for VTOL

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CENTRAL DATA PROCESSOR for AIR TRAFFIC CONTROL

Today, at a peak traffic hour, approximately 200 aircraft flew over the New York area. Each year this number will increase. Yet, the Federal Aviation Agency will continue to assure safe and efficient control of air traffic. One reason . . . a data processor developed for the FAA by Librascope to quickly and accurately handle the routine clerical tasks now occupying most of the controller's time. The first 18-unit data processor will be installed at Boston in 1962. A note to Librascope outlining your control problems will bring a prompt answer from the country's most versatile manufacturer of computer control systems.

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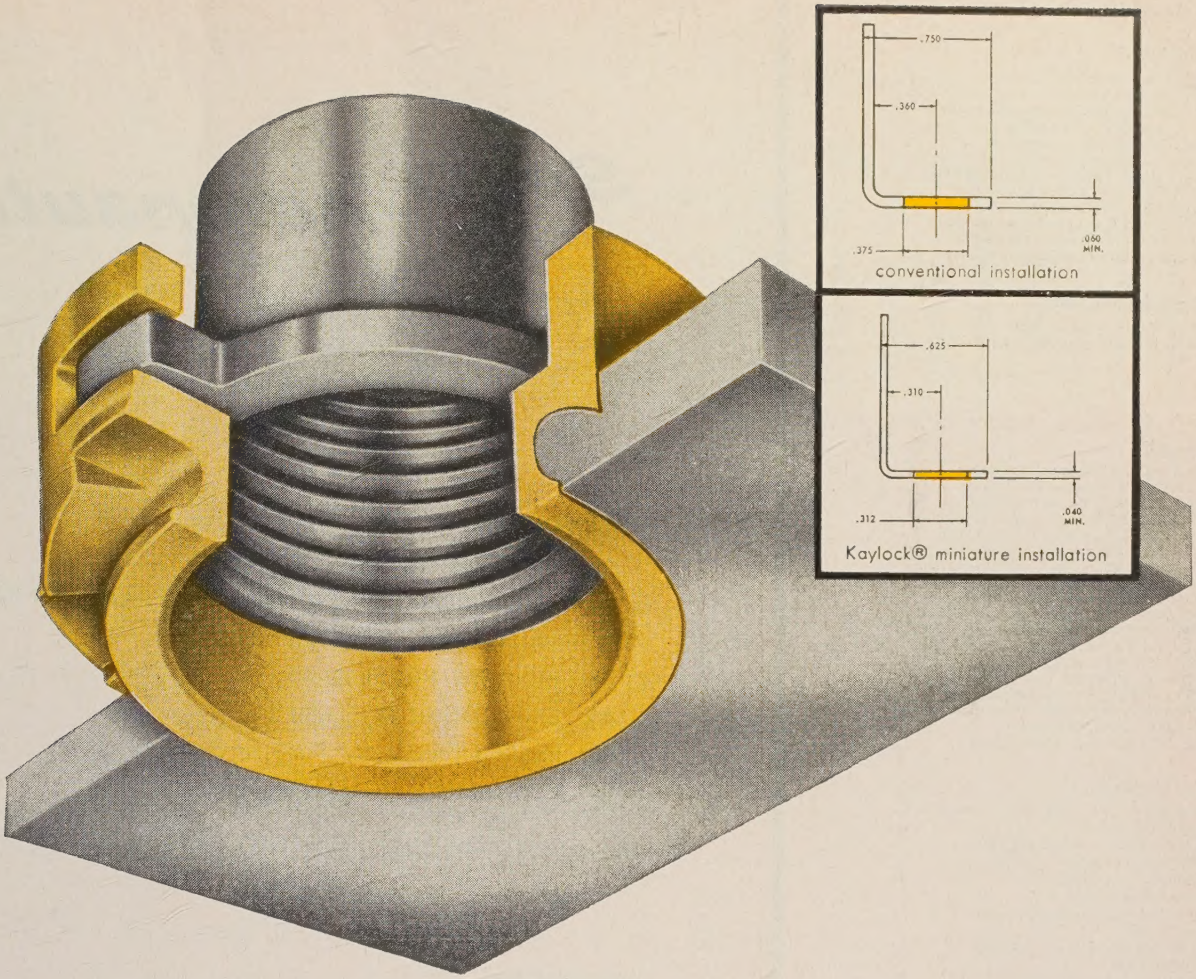

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The new Kaylock® Miniature Stake Nuts bear the unmistakable mark of Kaynar's leadership in aerospace fastener weight and space savings. These new miniatures answer the critical need for installed reliability of threaded elements in minimum thickness materials...can save you up to 33% of hardware weight. Additional savings can accrue as a result of thinner parent material requirements (.030 minimum thickness for Kaylock Non-Floating Stake Nuts, .040 minimum for Floating Stake Nuts.)

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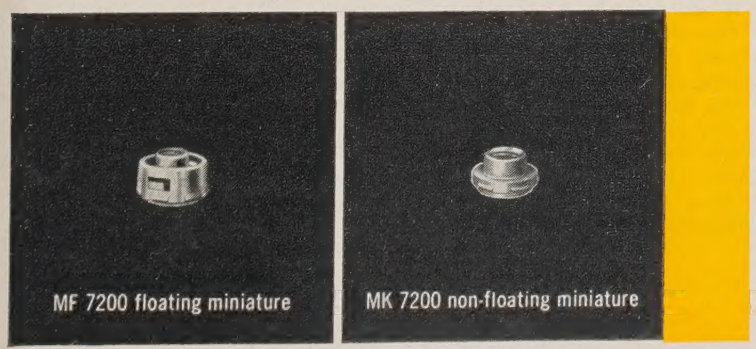

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OTHER PUBLICATIONS:
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If you want to get more information on any of the products or capabilities advertised or covered editorially in this issue, all you need is a pencil. Just note the key numbers of the items you are interested in on one of the Reader Service Cards in the front and the back of the magazine. Then fill in your name, title, company, and address, tear out the Card, and mail it (no postage necessary). Our Reader Service Department will take it from there and alert any company on whose products or capabilities you want to have more details. If you are interested in employment opportunities, the form on page 145 is just as easy to use.

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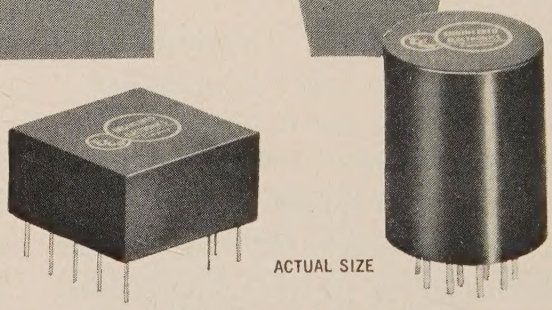
COMING

The bizarre environmental conditions of outer space pose unprecedented reliability and longevity problems for communications satellites. Next month's issue will feature a rundown on what we know about the space environment and discuss satellite components, design, and orbits. ■ What do you want to know about heat-sink techniques? Whatever it is, chances are you'll find it in S/A's coming article on thermal design, a tools-of-the-trade survey for electronic engineers. ■ We've reached a point in the development of pressure vessels for solid-propellant rocket motor cases where further progress may be restricted by lack of high-strength metals. Tape-wrapped titanium vessels offer a new breakthrough to be described next month. ■ The nuts and bolts hardware that will hold the spacecraft of the future together is liable to look much different, and be of different composition, from that of today. An article next month will describe a current program to develop fasteners for aerospace vehicles that can withstand extreme environments, and to evolve efficient and cheap production methods.

NEW



EECO NOR CIRCUITS

FROM LOGIC EQUATION TO SYSTEM PROTOTYPE IN ONE STEP

That's how simple it can be when EECO's new U-Series Digital NOR-Circuit modules are used. Engineering time can be spent designing **systems**, because EECO has taken care of circuit details. The first units of this new family of compatible germanium transistor circuit modules operate over the frequency range of 0 to 25 kcs. These units are designed to meet the requirements of MIL-STD-202B, as modified by temperature specifications of individual units.

PACKAGING

Two packaging styles are available. Both use **all-welded** electrical connections and both are encapsulated. Rectangular units with wire leads (to simplify dip-soldering) are available for installation on circuit cards. Cylindrical units with pins are available for installation in tube-type sockets. This latter package is admirably suited for system breadboarding. System wiring can be accomplished at the sockets; modifications in system design can be performed easily and rapidly. The cylindrical packages measure 7/8″ diameter by 1.0″ seated height. The rectangular packages measure 0.95″ long by 0.95″ wide by 0.5″ seated height.

Write, wire, or phone today for detailed information on the EECO U-Series of NOR units or for information on any of our other families of digital circuit modules.

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technical articles in this issue abstracts

Technical Management

Pert and Pep: useful management tools or timewasters?

The Pert and Pep program evaluation techniques are called a management "breakthrough" in project control by the military services. Industry people experienced in the use of Pert give their ideas on the system's advantages and limitations.

by Randolph Hawthorne, Editor

space/aeronautics 36/2 (Aug. '61) p. 56

Accessory Systems, Propulsion, Electronics, Systems Engineering

Simple chamber pivoting enough for Black Knight control

Describes the systems and components used in the control and guidance of Britain's first true ballistic missile. Emphasis is on simplicity and the use of well-tried components to achieve reliability.

by Christopher Dawson, Associate Editor

space/aeronautics 36/2 (Aug. '61) p. 75

Systems Engineering, Propulsion, Structures, Electronics

Simplicity boosts Able-Star to reliability record

Detailed design analysis of the Able-Star upper-stage system. Analyzes how maximum reliability was insured in overall structural arrangement, handling of applied loads, engine configuration, electronics package, and control of start, restart, and attitude.

by Irwin Stambler, Associate Editor

space/aeronautics 36/2 (Aug. '61) p. 59

Testing, Nuclear Engineering, Accessory Systems, Accessory Components

Radioactive testing of accelerometer takes two large facilities

Reviews recent nuclear test series run on an accelerometer. Discusses facilities and techniques needed for testing, and the effect of a radiation environment upon criteria for materials, configuration, and insulation.

by Dale C. Baker, Giannini Controls

space/aeronautics 36/2 (Aug. '61) p. 85

Propulsion, Systems Engineering, Accessory Systems

Lift fans: cheap, flexible and light VTOL propulsion

Describes GE's X353-5 lift fan. Designed for thin wings, the X353-5 is said to secure most of the advantages—in weight, control, power conversion, and fuel consumption—of this type of system.

by B. H. Rowe, General Electric

space/aeronautics 36/2 (Aug. '61) p. 65

Electronics

Plasmas: circuit elements for future electronics?

Discusses plasmas as dielectric circuit elements for electromagnetic waves. Describes a procedure for determining plasma characteristics and their reaction within electromagnetic fields, and analyzes this procedure for four different cases of electromagnetic-wave propagation in a plasma.

by James E. Hopson, General Telephone & Electronics Laboratories

space/aeronautics 36/2 (Aug. '61) p. 112

Accessory Systems, Human Factors, Electronics

Luminous bar indicators cut down readout errors

Design analysis of the "electroluminescent vertical indicator system" (Elvis) using a fixed transparent electrode and a mercury column as a movable and opaque electrode. The use of color in this display and applications for analog function generation and analog-digital conversion are also analyzed.

by Albert L. deGraffenried, Avien

space/aeronautics 36/2 (Aug. '61) p. 70

Electronics

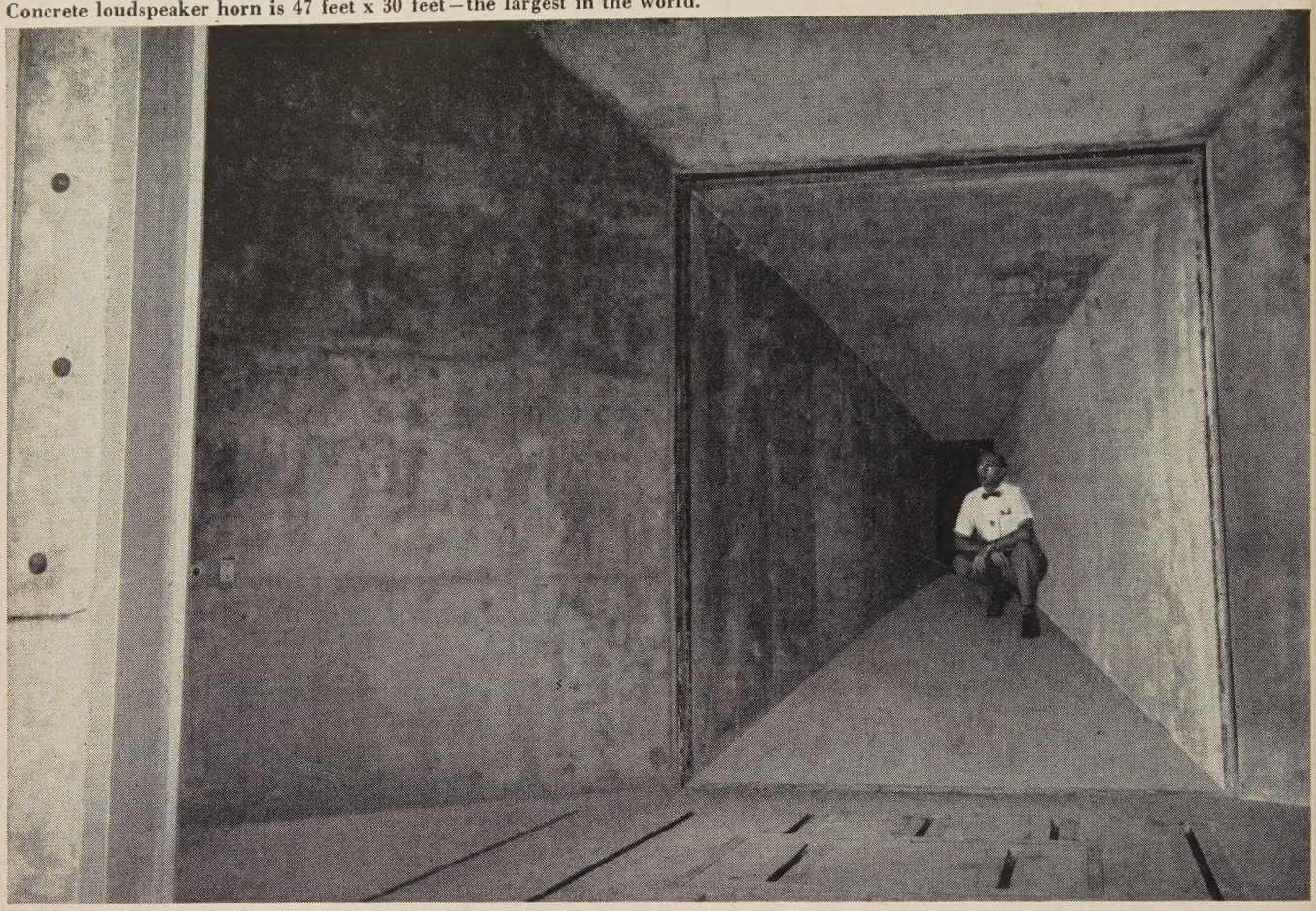
Multivibrators built with thin films

Reports on a series of free-running, thin-film multivibrators with basic frequencies of 1800 to 10,800 cps said to go far toward overcoming the problems of mounting, size, and connections created by microminiaturization.

by H. J. Weber, Servomechanisms

space/aeronautics 36/2 (Aug. '61) p. 118

Concrete loudspeaker horn is 47 feet x 30 feet—the largest in the world.



Mach 3 Technology

Torturing aircraft structures with the world's largest "gramaphone"

To predetermine in-flight stresses on an aircraft as advanced as the Air Force's Mach 3 B-70 Valkyrie, it was necessary to make sweeping advances in the state-of-the-art of testing procedures.

One way the Los Angeles Division of North American Aviation met this challenge was to build the largest, loudest acoustical test chamber in the world. Here, a mammoth 47 foot by 30 foot concrete loudspeaker horn can blast aircraft structural specimens with up to 170 decibels of noise. This is the equivalent of 54,000 five-tube radios going full blast, yet ingenious soundproofing keeps this noise to no more than a discreet whisper outside the lab. The noise inside the lab is so great that the heat generated could ignite fiber glass insulating material.

Specimens up to 6 feet by 25 feet can be tested in the acoustical lab. It has the capacity for: progressive wave as well as reverberant sound fields; grazing or normal incidence specimen orientation; discrete frequency or random noise at sound levels up to 170 dbs; thermal environment testing from $-100°F$ to $+1200°F$; frequencies of 50 to 10,000 cycles per second. This is indeed a remarkable facility for acoustical testing, fatigue testing, and vibration testing.

This giant acoustical laboratory can not only carry out testing on tomorrow's Mach 3 aircraft, but can perform tests on aerospace craft still ten years from reality. The lab is only one of the many that the Los Angeles Division has developed to conquer problems of space age flight.

Builders of the B-70 Valkyrie

THE LOS ANGELES DIVISION OF NORTH AMERICAN AVIATION

abstracts

continued from page 7

Electronics

Track-while-scan IR system for automatic threat evaluation (Design Digest)

Reports on series of advanced passive IR scanning and tracking systems for the 3.5-5.5 micron region, an outgrowth of Avco's Avscan design. A digital computer subsystem tracks single or multiple targets and periodically computes their position.

by Bernard Kovit, Associate Electronics Editor

space/aeronautics 36/2 (Aug. '61) p. 123

Accessory Systems, Test Engineering

Nine-channel thermocouple compensator system

Reviews temperature compensation system consisting of zone boxes, zone-box adapter module, and bridge circuit cards. The system is accurate within six degrees from 32 to 165 deg F.

space/aeronautics 36/2 (Aug. '61) p. 169

Electronics, Accessory Systems

IR instrumentation a sure bet for spacecraft

Reviews use of passive infrared sensing systems for attitude sensing and meteorological charting of radiation patterns, as well as IR instruments designed for terminal guidance in planet landings.

by Eric M. Wormser, Barnes Engineering

space/aeronautics 36/2 (Aug. '61) p. 127

Test Engineering, Materials

Siren-type noise generators test acoustic fatigue

Describes acoustic noise-generating system that produces sound pressure levels of more than 164 db in one-foot-square test section. Data are given on three models.

space/aeronautics 36/2 (Aug. '61) p. 201

Production Engineering

Jumbo tape-controlled system measures precision parts

Describes numerically controlled 16-ton, five-axis measuring machine. Variations as small as 0.00001 in. can be detected in ID, OD, and thickness of rotating parts.

space/aeronautics 36/2 (Aug. '61) p. 155

Electronics

Modular collapsible antennas for quick-erection functions

Reviews four-element-array antenna for 350-600 mc in communications, surveillance, and other applications.

space/aeronautics 36/2 (Aug. '61) p. 217

R&D Technical Handbook

A limited supply of copies of the 1961-62 R & D Technical Handbook, published last month, is available at $5 per copy. Just fill in the order form at right and send it to us **with your remittance.**

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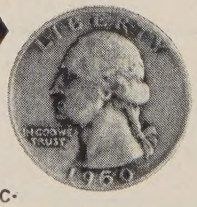

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product index to advertising

THIS IS A SPECIAL REFERENCE to the product information given in the advertisements in this issue. It is intended solely to help the reader make the best use of these ads. Therefore the index does not necessarily cover all the products made by each advertiser. Also, definitions and cross-listings are not intended to exhaustively describe each product but merely to make sure that each product can be found with reasonable ease by the reader looking for it.

Similar indexes to services and employment opportunities featured in ads follow this index.

Advertisements for which complete proofs were not available to the Editorial Department by the closing date are not necessarily covered by these indexes. (Proofs can be forwarded internally by the Production Department only for advertisements meeting the closing dates.)

For more detailed information on any product or service advertised in this issue or featured in its Product and Data Reviews, use the handy Reader Service Card.

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these are men you should know . . . Delavan fuel injection specialists

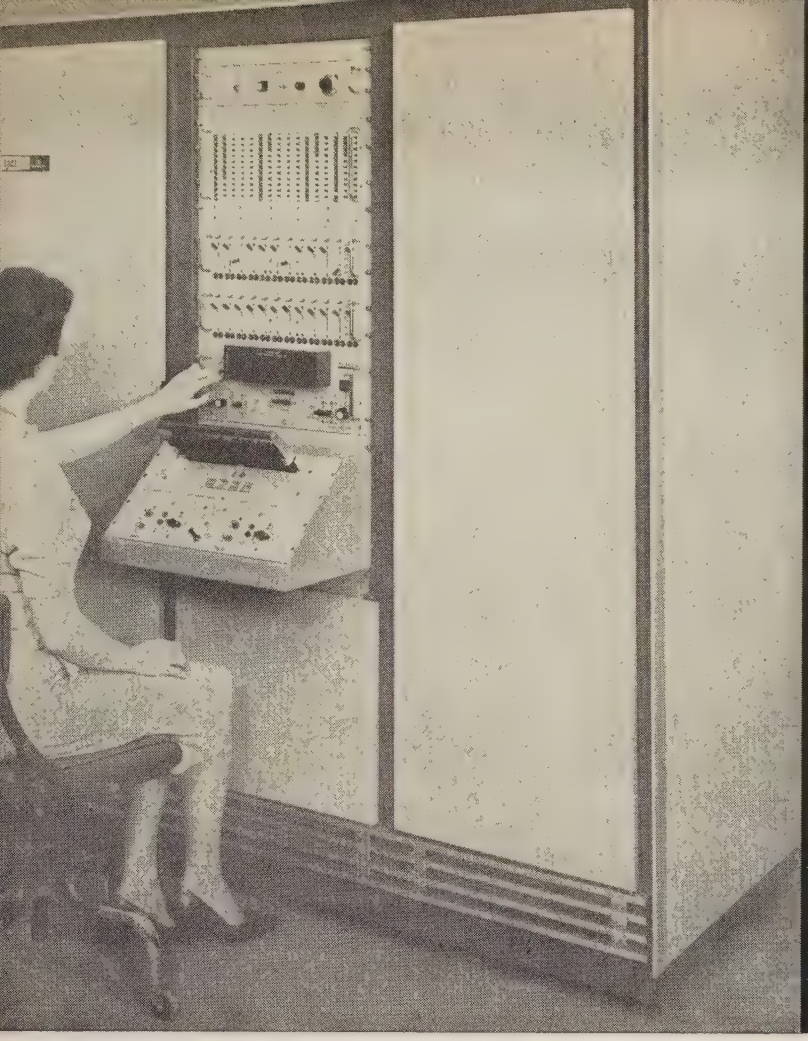
CREATIVE DESIGN IS THEIR RESPONSIBILITY

Doing something better than it's ever been done before is the essence of successful, creative design. These Delavan men . . . Don Sill, Project Engineer, and Jim Brucker, Senior Project Engineer . . . approach each problem with this goal in mind. The result of their work on afterburner and main engine fuel injectors is reflected in Delavan's acceptance among leading engine manufacturers. From the early beginnings of gas turbine engines, Delavan has been designing and producing fuel nozzles. Proof of this specialized ability is that Delavan has produced more than a million fuel nozzle injectors, and is specified on 11 engines currently in production. This proven ability to design and manufacture uniform, high performance nozzles is important to you.

get to know these Delavan fuel injection specialists

DELAVAN
Manufacturing Company
WEST DES MOINES • IOWA

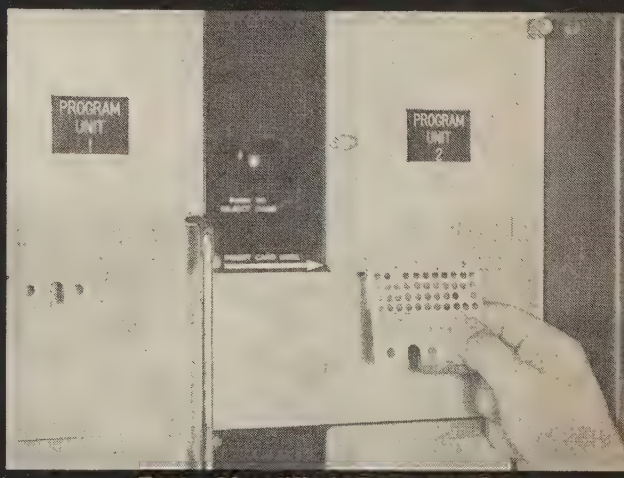
No. 5 on Reader Service Card



new from TI

tact

TRANSISTOR AND COMPONENT TESTER



Fast, Simplified Programming With Punched Cards

MAXIMUM VERSATILITY *PLUS* ECONOMY

tact BUILDING-BLOCK DESIGN GIVES YOU BOTH!

TACT is a universally applicable transistor and component tester that will meet both present and future requirements without undue investment. It is a sequentially controlled system which advances through as many as 24 test parameters, applying pre-programmed test limits and visually reading out and/or recording measured results. Time-proved test circuitry is combined with punched-card programming to produce a highly accurate system of high sequential testing speeds.

TACT systems won't become obsolete—can be expanded to accommodate future tests or extended to testing printed circuit boards, modular circuits, etc.

High Testing Accuracy results from reduction of readout and signal cable leakage and interference. Test circuitry cabling has been reduced to approximately one-tenth of other designs offering similar testing capabilities.

Repeatability of Testing is maximized by punched-card programming and remote control of common test circuitry. Program cards can be retained and used indefinitely, assuring high repeatability and a permanent record of test conditions.

Nontechnical Personnel can operate TACT systems with minimum training. Reprogramming can be accomplished in minutes without circuit board or plug-in unit changes.

APPARATUS DIVISION
PLANTS IN HOUSTON
AND DALLAS, TEXAS

TEXAS INSTRUMENTS
INCORPORATED
3609 BUFFALO SPEEDWAY
P. O. BOX 6027 HOUSTON 6, TEXAS

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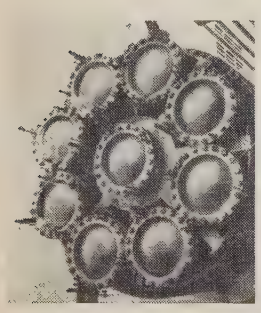
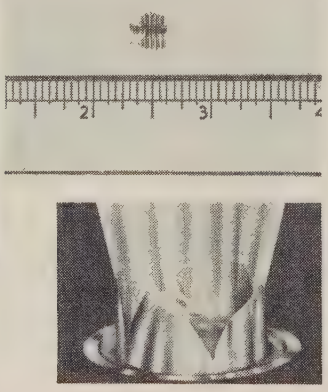
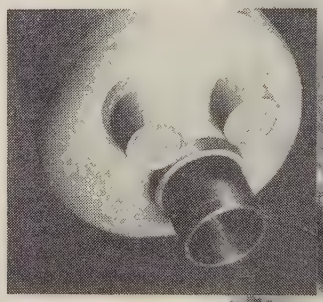
QUICK-OPENING VALVE ... OR OVER-PRESSURE PROTECTION ...

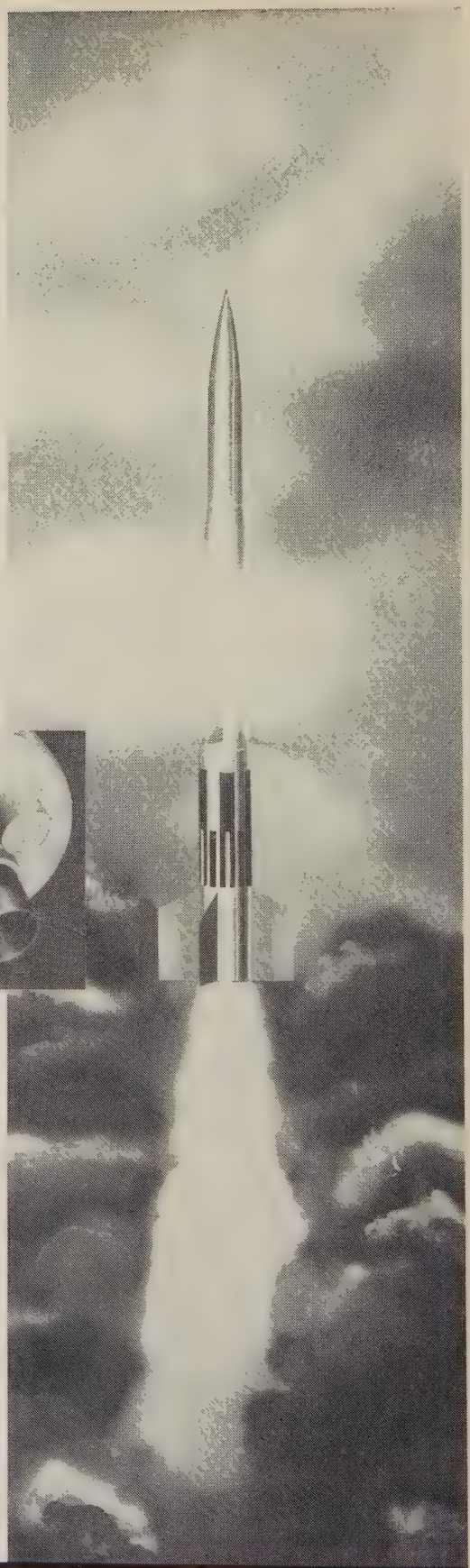
The BS&B Safety Head (rupture disc) will fit into most any pressure system that needs to be controlled or protected. For example, BS&B Safety Heads are now being used on Jato bottles, pilot ejection systems, fuel oxidation systems and missile hydraulic systems, serving as over-pressure protection or functioning as a quick opening valve.

A few years ago none of those uses were known. But as the industry has grown, and as new problems ... both of a functional and control nature ... developed, uses of rupture discs provided solutions to the problems of the aero/space industry.









The safety head is a light-weight metal disc enclosed in a holding mechanism ... a flange or suitable placement device. This thin metal membrane will fracture or rupture at a pre-determined pressure to provide an instantaneous and complete opening. Various metals and plastic coatings render it virtually immune to corrosive chemical action.

We invite you to submit your problems on functional or over-pressure control to our Engineering Department. We will assist you in selecting a safety head of suitable design for your service requirement. Contact your local BS&B office, or write to: Dept. 2-HB8, 7500 East 12th Street, Kansas City 26, Missouri.

BS&B

BLACK, SIVALLS & BRYSON

KANSAS CITY • OKLAHOMA CITY • TULSA • EDMONTON • THE HAGUE

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WHITE GLOVE INSPECTION

The Stratoflex Testing Laboratory continually evaluates products on a development and surveillance basis, the capability of hose assemblies to withstand prolonged conditions of heat, cold, thermal shock, hydraulic impulse, vibration, flexing, pressure, elongation and contraction, fluid resistance, vacuum and other tests. In fact, WHITE GLOVE INSPECTION IS ROUTINE OF STRATOFLEX PRODUCTS.

Every fluid line assembly ordered by a Stratoflex customer has been manufactured to rigid specifications and has been carefully inspected and tested to assure the highest standard of quality and performance.

Engineers in the Stratoflex Testing Laboratory utilize the most modern and precise equipment available. This equipment exposes fluid and pneumatic hose lines to conditions beyond those encountered in specific applications.

For your requirements for hose and fittings that perform with complete reliability, regardless of fluid line requirements, contact your nearest Stratoflex Representative.

STRATOFLEX Inc.

P.O. Box 10398 • Fort Worth, Texas
Branch Plants: Hawthorne, Calif., Fort Wayne, Ind.
In Canada: Stratoflex of Canada, Inc.
In Great Britain: Stratoflex (U.K.) Ltd.

SALES OFFICES:
Atlanta, Chicago
Cleveland, Dayton
Detroit, Fort Wayne
Fort Worth, Hawthorne
Houston, Kansas City
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No. 8 on Reader Service Card

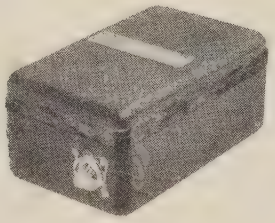
BARBER COLMAN

CONTROL SYSTEMS

AIR VALVES

ACTUATORS

ENCLOSURES



Temperature Controls

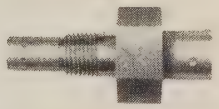
Cycling—proportioning—floating; electronic . . . transistor . . . polarized relay . . . and magnetic amplifier types. Also CEDAC, the original cooling effect detection and control system.

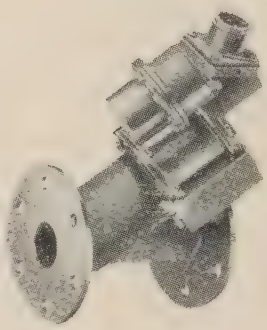
Positioning Controls

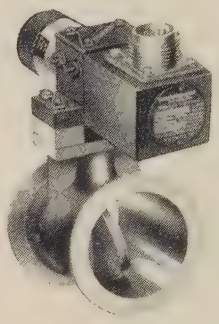
Integrated, highly sensitive remote positioning systems designed to your specifications. Magnetic amplifier, electric, and electronic types. Anti-hunt feature provided by unique circuitry.

Transducers and Thermostats

Units for sensing compartment, duct, and windshield temperatures. CEDAC detectors for sensing temperature and airflow.

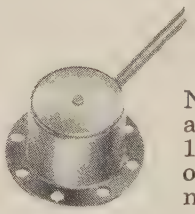






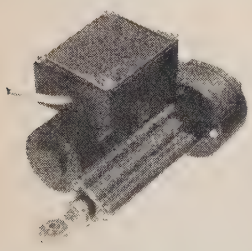
Air Valves

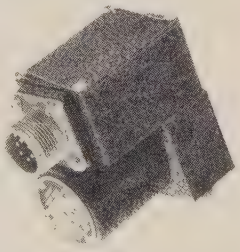
Electrically and pneumatically operated for temperature and pressure-control applications. Butterfly . . . check . . . poppet . . . and automatic drain types. Metallurgically proved materials and precision machining assure long, trouble-free operation.



Solenoids

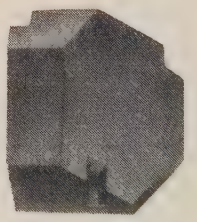
New hermetically sealed, high-temperature type . . . operate 1000 hr at 1000° F. Can be used with devices operating at temperatures previously nonaccessible.

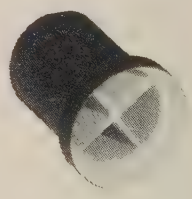




Electromechanical Actuators

Rotary and linear types featuring a wide range of gear reductions, switching, mounting details. The complete Barber-Colman line includes new lightweight, compact actuators for extra spacesaving, weightsaving advantages. Torque limit as well as travel limit versions.





New POLYFORM metal enclosures solve unusual envelope problems. Precision formed in one piece to virtually any configuration . . . to fit odd-shaped, limited areas in missiles, other air vehicles, and various types of complex electronic gear. Provides better electromagnetic shielding for less weight.

SEE OUR SPECIFICATIONS IN VSMF THE MICROFILM CATALOG FILE

For expert assistance on your projects, consult the Barber-Colman engineering sales office nearest you: Baltimore, Boston, Dayton, Fort Worth, Los Angeles, Montreal, New York, Rockford, San Diego, Seattle, Winter Park, Florida.

Send for complete catalog to:

BARBER-COLMAN COMPANY

Aircraft and Missile Products Division, Dept. T, 1423 Rock Street, Rockford, Illinois

No. 9 on Reader Service Card

WHERE...

WHAT...

WHO...

No matter where it's going — what it is — or who it is

Reeves CAN TRACK IT

Reeves offers more than fifteen years of comprehensive experience in the design, development, and production of radar tracking and guidance systems. Early achievements include the X-1 and Gunnar fire control systems; MSQ-1A close support system, and Matador and Terrier guidance radars.

Current Reeves radar developments include VERLORT (Very Long Range Tracking) radars, capable of tracking to ranges of 5000 miles and more. These versatile radars, stationed at tracking ranges around the earth, will follow the first American "man-in-space" as he orbits in the MERCURY satellite.

Complete Radar Systems

- Acquisition
- Long Range Tracking
- Guidance
- Telemetry
- Close Support
- Fire Control

In addition to complete radar systems, Reeves also produces extremely accurate two- and three-axis antenna pedestals for control, guidance, and tracking applications. For a copy of our new Pedestal Brochure, write on your company letterhead for data file **808.**

Qualified engineers seeking rewarding opportunities in these advanced fields are invited to get in touch with us.

Reeves

REEVES INSTRUMENT CORPORATION

A Subsidiary of Dynamics Corporation of America, Roosevelt Field, Garden City, N.Y.

3 times the speed of sound ...on the ground!

This fuel-system flight simulator at TAPCO duplicates the rugged airborne conditions specified by the designers of an advanced Mach 3 bomber.

The objective: to confirm that the TAPCO fuel pumps will perform unfailingly, providing vapor-free fuel when subjected to the extremes of temperatures, pressures and maneuvers they will encounter in actual flight.

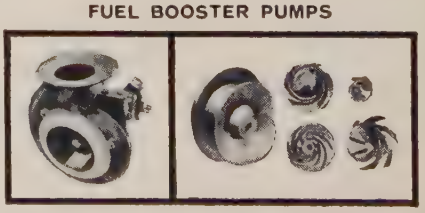
All TAPCO pump designs—for advanced fighters, trainers, commercial airliners, helicopters, business and utility aircraft —are environment tested on simulators like this—a concept of painstaking thoroughness that TAPCO engineers maintain from research to design, through development to manufacture and service.

Twenty years of TAPCO experience supports that concept. Experience that pioneered booster pumps—that helped the old C-46 to conquer the "Burma Hump" during World War II—and that has since provided more than *one million* pumps for every type of aircraft in the world . . . or out of it!

For information on new fuel systems and components to meet your requirements and for data on current TAPCO centrifugal pumps, write:

Most aircraft flying today use TAPCO pumps to feed their engines. Among them: BOEING 707, 720 and B-52; NORTH AMERICAN A3J; LOCKHEED F-104; GRUMMAN W2F-1; NORTHROP T-38; REPUBLIC F-105; CONVAIR B-58, F-106, 880 and 990; DE HAVILAND Beaver, Otter and Caribou; SUD AVIATION Caravelle Series; ARMSTRONG WHITWORTH Argosy; VICKERS-ARMSTRONG Viscounts; FUJI T1F2; and SAAB Larsen and Draken.

FUEL BOOSTER PUMPS



TAPCO A DIVISION OF ***Thompson Ramo Wooldridge Inc.***

DEPT. SA-861, CLEVELAND 17, OHIO

DESIGNERS AND MANUFACTURERS FOR THE AIRCRAFT, MISSILE, SPACE, ORDNANCE, ELECTRONIC AND NUCLEAR INDUSTRIES

TAPCO EXPORT SPARE PARTS AND LOGISTICS SUPPORT REPRESENTATIVE: AMERICAN AVITRON INC., MAMARONECK, N. Y.

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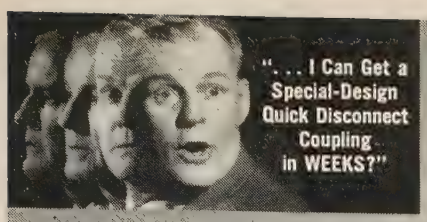
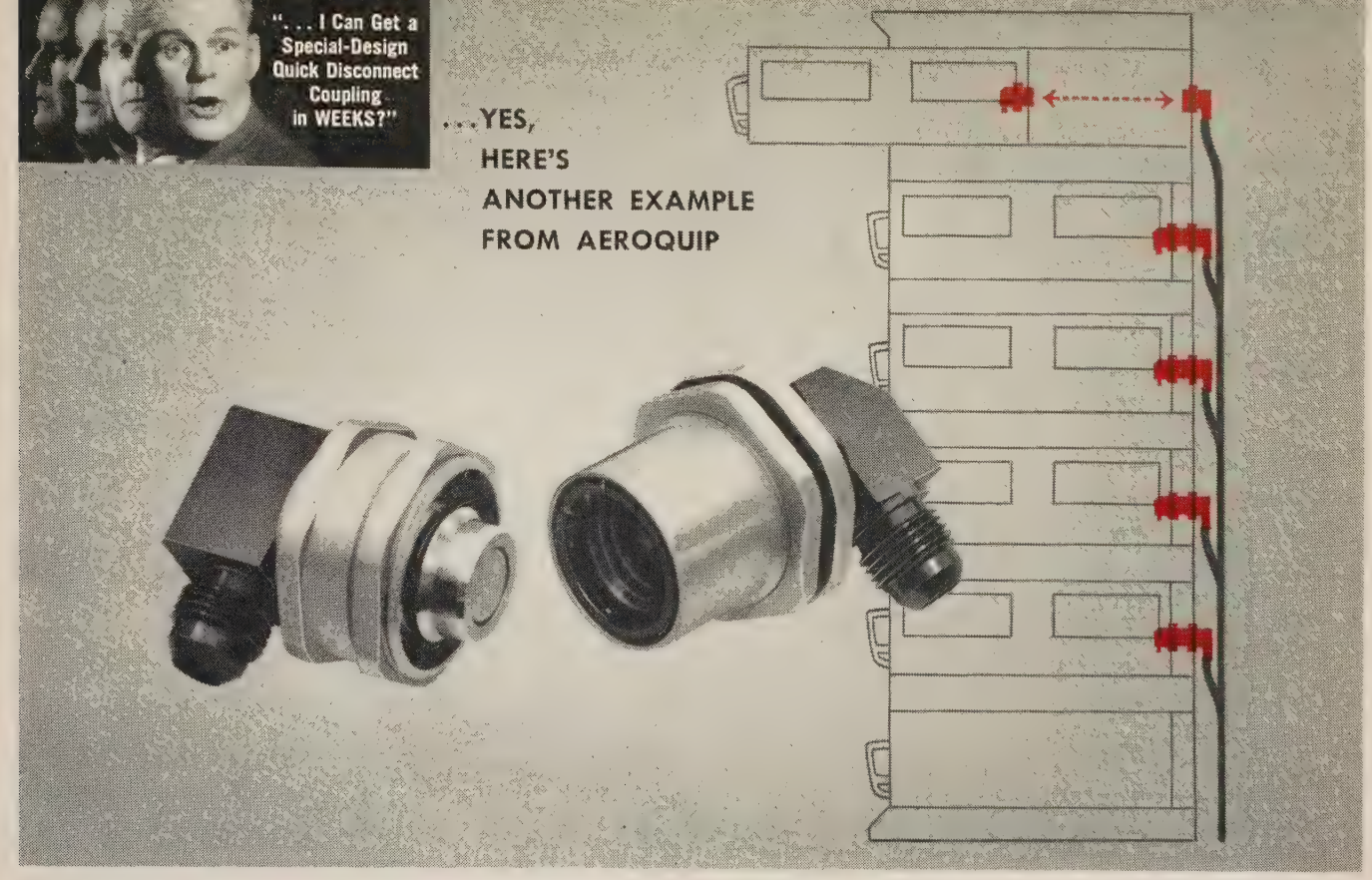


...YES, HERE'S ANOTHER EXAMPLE FROM AEROQUIP



Rack and Panel-Mounted Quick Disconnect for Electronic Modules is Automatic and Self-Sealing

PROVIDES COMPLETE RELIABILITY!

This coupling, designed and supplied by Aeroquip to customer requirements in the short span of a few weeks, is used to connect coolant fluid lines to airborne rack and panel-mounted electronic modules.

Design provides for integral mounting of coupling halves on the rack and back panel. Coupling connection and disconnection is automatically accomplished by closing or opening the drawer. The coupling is self aligning upon connection, accommodates over-under travel, and includes a capillary pressure relief port. The no air inclusion, no fluid loss valving eliminates spillage of fluid on electronic components.

Other features include compatibility with most dielectric fluids and systems with pressures to 500 psi and fluid temperatures of −65° to +350°F. All these features are incorporated in a 4″ long coupling weighing only 4¾ ounces.

This is one more example of Aeroquip's coupling design capability, which has provided hundreds of special quick disconnects for a wide range of applications. This capability is at your service in designing couplings for your special applications. For information return the coupon below.

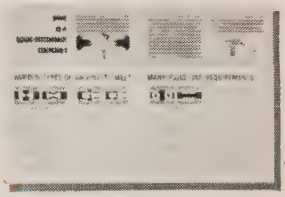
PUSH-PULL and SAF-LOC are Aeroquip Trademarks

COUPLINGS FOR THESE FLUIDS:

- HYDRAULICS
- PNEUMATICS
- FUEL
- LUBE OIL
- CORROSIVE FLUIDS
- GASES AND
- ELECTRONIC COOLANTS

THESE COUPLING TYPES:

- THREADED
- PUSH-PULL
- BREAKAWAY
- REMOTE CONTROL
- SELF-SEALING
- MINIATURIZED
- SAF-LOC
- . . . AND MANY OTHER TYPES



Aeroquip

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AEROQUIP PRODUCTS ARE PROTECTED BY PATENTS IN U.S.A. AND ABROAD

Aeroquip Corporation, Jackson, Mich.
Please send me a copy of Bulletin No. 254 SA-8

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Would you like to talk to a sales engineer about your application? ☐ Yes

No. 11 on Reader Service Card

"SCOTCHFOAM" Brand vibration damping tape

New "SCOTCHFOAM" Damping Tape provides unusually good resonance control where sound and vibration pose a problem. The secret of the tape is its unique combination of plastic foam and adhesive on a reinforced vinyl backing. And, because "SCOTCHFOAM" Tape controls resonance, it also protects metal and other materials from vibration fatigue. The water glasses shown above are a simple demonstration. Far more dramatic, however, is the result when you line an aircraft fuselage with this easily applied product. It is light in weight . . . just four ounces per square foot in ¼" thickness. In addition to soaking up vibration energy "SCOTCHFOAM" Tape insulates against heat and is highly resistant to moisture. For more information and samples, ask your 3M Representative or write: 3M Co., 900 Bush Ave., St. Paul 6, Minn., Dept. IBL-81.

MINNESOTA MINING AND MANUFACTURING COMPANY
...WHERE RESEARCH IS THE KEY TO TOMORROW

3M COMPANY

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No. 161 on Reader Service Card

BENDIX CHROME COMPOSITE

unusual strength and good oxidation resistance in 2000° F. to 3000° F. range

Effective space age "armor" to protect missile components during atmospheric re-entry is in the making at Bendix. Nose caps, probes and leading edges of Chrome Composite resist the destructive combination of heat and oxidation encountered in space exploration.

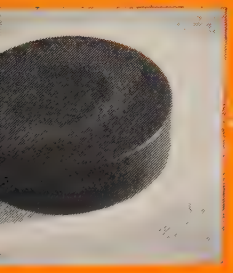
This unique material combines strength and hardness with weight-saving advantages. In addition, it can be forged, hot worked and machined by conventional methods and equipment.

For information on this remarkable new material and on the Bendix design, development and testing facilities geared to the space age, write to Composite Materials Sales Department . . .

Bendix PRODUCTS DIVISION South Bend, IND.

THE Bendix CORPORATION

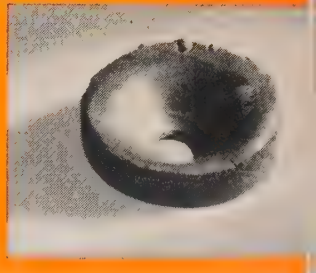
Photos below: material samples exposed to supersonic jet torch at a heat flux of 400 btu/ft²/sec. (approximately 3000°F.)



ome Composite
inute exposure

Graphite
4-minute exposure

Molybdenum
45-second exposure



Chromium
3.5-minute exposure

Meet the

New DAYSTROM Man

Who Brings You Coordinated Procurement of Gyros . . . Servos . . . Synchros . . . Transducers

- He represents, as a sales engineer, not one, but *several* coordinated Divisions of Daystrom.
- He's trained and equipped to discuss product capabilities and application in *many* component areas.
- This flexibility enables him to serve you in many more ways—far more often—far more effectively—far more deeply, especially where work with engineering departments is required.
- He's backed up by the specialized field engineering forces of each of the divisions he represents.
- He brings you *unified responsibility*—in delivery, product quality and compatibility all of which equates with considerable economy for you.
- You'll find your Daystrom Sales Engineer helpful in more efficient component procurement. Make full use of his services. Call:

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Dayton, Ohio	AX 9-5241	West Caldwell, N. J.	CA 8-0240
Denver, Colo.	AC 2-4497		
Green Lawn, L. I., N. Y.	FI 7-6087	Gloucester, England	GL 20217
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Or write Coordinated Procurement Services, DAYSTROM INCORPORATED, West Caldwell, N. J.

DAYSTROM, INCORPORATED

DAYSTROM - PACIFIC: vertical, free, and rate gyros • programmers • data recorders
DAYSTROM - TRANSICOIL: servo and synchro components • electromechanical assemblies • airborne instrumentation
DAYSTROM - WIANCKO: transducers for sensing pressure, force, acceleration • analog and digital dynamic measuring systems
OTHER PARTICIPATING DIVISIONS: ELECTRIC DIVISION • MILITARY ELECTRONICS DIVISION • WESTON DIVISION • CONTROL SYSTEMS DIVISION

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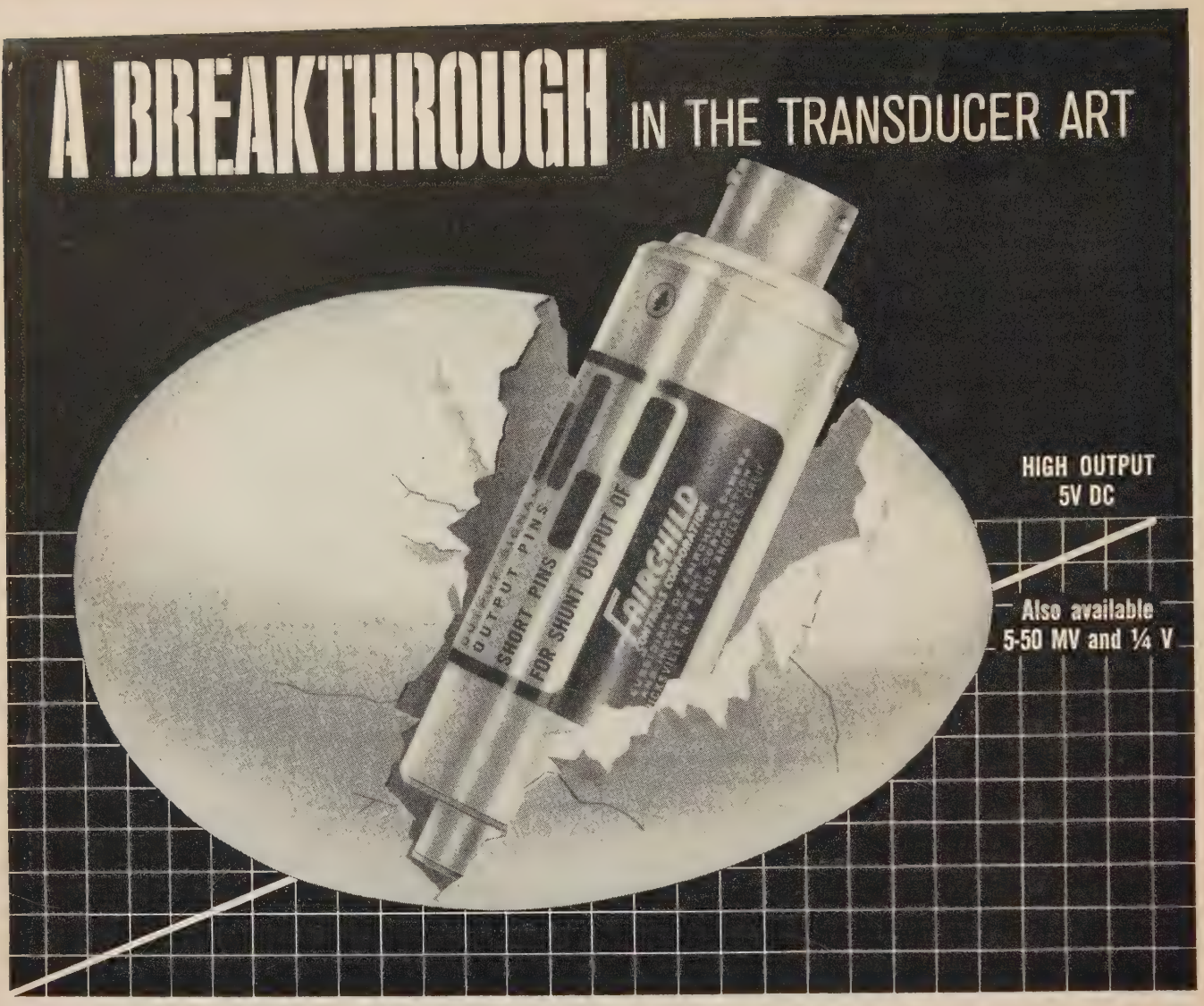
A BREAKTHROUGH IN THE TRANSDUCER ART



3S-G SILICON SEMICONDUCTOR

STRAIN GAGE PRESSURE TRANSDUCER

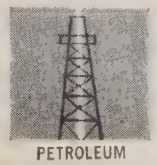
Outstanding features:

- HIGH OUTPUT d-c SIGNAL
- EXCEPTIONAL ACCURACY
- MAXIMUM RELIABILITY
- INFINITE RESOLUTION
- SELF CONTAINED CALIBRATION
- TEMPERATURE COMPENSATED
- UNEXCELLED REPEATABILITY
- RUGGEDIZED

The Fairchild 3S-G is the first and only pressure transducer with a 5V DC output signal that uses semiconductor materials having piezoresistive characteristics as a transducer sensing element. It is also available with low level outputs of 5-50 MV and ¼ V. This revolutionary transducer is extremely accurate, has an operable temperature range of —65° to 250°F, and is responsive to both static and high frequency dynamic pressures from 0-100 through 0-10,000 psig and psia. It is fully compatible with existing military air, ground and underwater telemetry and industrial systems and resistant to all gaseous and liquid media, including liquid oxygen, strong alkalies, corrosive acids and high energy fuels. Airborne and ruggedized designs are available; both can withstand 35 G's vibration to 2,000 cps with negligible effect. For information on the application of the silicon semiconductor strain gage pressure transducers to your system requirements, **Fairchild Controls Corp. Dept. 50 SA.**

wide application in control systems for defense and industry

STEEL


PETROLEUM

CHEMICAL

MISSILE

UNDERWATER

FAIRCHILD CONTROLS CORPORATION

A Subsidiary of Fairchild Camera and Instrument Corporation

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Facing up to R&D

OFFICIALLY, the emphasis in the aerospace industry has largely shifted from production to research and development. It says so in the speeches of the leaders of government and industry, and it says so in the statistics of project starts, of companies working exclusively on R&D, and of R&D groups within the major aerospace companies.

We wonder, though, whether the aerospace industry in its everyday operation has actually faced up this shift in emphasis. We spent a day recently with some top-level people from one of the Defense Department's most important research groups, and some of the things we were told set us back a little. One was the story, told by one of the DOD researchers, of his struggle with a contractor who wanted to announce that he was working on a system that could shoot down missiles by the dozen, when in reality he was working on a feasibility model that, *if* it proves out, *might sometime in the future* lead to a weapon that indeed could shoot down a lot of missiles. Another was one of the reasons the group gave for its disinclination to release information about its research activities, all of which are years away from production. Too often when it has released such information, industry has misinterpreted it as a sign of impending production contracts and flooded the group with queries and proposals that had nothing to do with R&D.

THE DANGERS of misunderstandings within the industry itself about the role and nature of R&D are fairly obvious and serious. If aerospace companies in their public statements boost the production work of which they are doing less at the expense of the R&D work of which they are doing more, the public will go right along with them—hardware is easier to understand than R&D. Then, when the hardware doesn't live up to the publicity, there'll be disappointment and the industry will be in trouble. Since the aerospace industry can't possibly tell the public and its representatives on Capitol Hill to go to hell, it had better not add to the distortion of its image in the public's mind.

Preoccupation with production could have even worse effects on the researchers, who are human, too, and don't like to be misunderstood. It might scare them back into their ivory tower. Nobody in the aerospace industry needs to be told what would happen to the already exasperating problem of getting technical information to all the people who need it if the researchers refused to talk to anyone known to have uttered the word "production" within living memory.

Of course, there's another side to this picture. As things stand today, production contracts are much more profitable than R&D contracts, and it's a bit rough on a company when it is asked to de-emphasize the kind of work that brings in the most money.

Nevertheless, who is to start acknowledging the role of R&D in the aerospace industry if not the industry itself? R&D assuredly deserves more recognition—financially and otherwise—but the public and its representatives will give it only if the industry leads the way.

Today, it is mostly the researchers who are misunderstood. If the industry ignores or glosses over the importance and special nature of R&D, soon the industry itself will be misunderstood.

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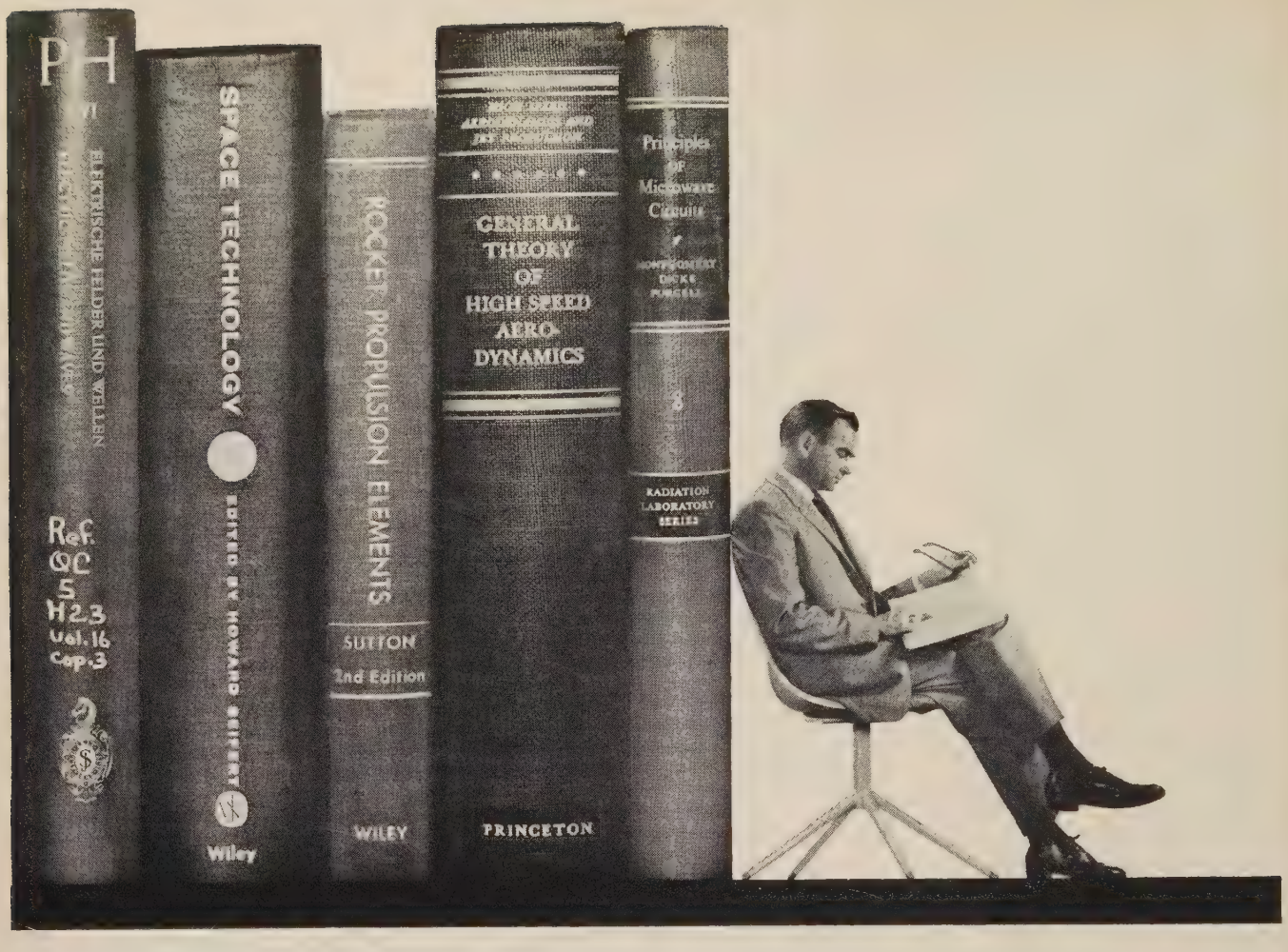

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More military advice for Kennedy?

GEN, MAXWELL TAYLOR's appointment as Mr. Kennedy's personal military advisor with an office in the White House **may well mean that the President feels he has not been getting enough strictly military advice.**

President Kennedy is making **far greater use** of scientists and university professors to reach national security decisions than General Eisenhower did during his eight-year tenure.

From all appearances, the "egghead" group advising Mr. Kennedy on scientific aspects of defense is neither better nor worse than its predecessors. But Gen. Taylor's appointment **does** emphasize Mr. Kennedy's desire to augment his "egghead" advice with the thinking of a military professional.

Taylor, who retired after serving under Mr. Eisenhower as Army Chief of Staff and later expounded his views on current military strategy and the lack of preparation for para-military (guerilla-type) operations in a book and magazine articles, was first picked by Mr. Kennedy to ascertain what was wrong with CIA in its analysis of the Cuban invasion. His new White House post will not mean, as some have suggested, that there will be an immediate go-ahead for Nike-Zeus and other pet Army projects.

Mr. Kennedy's other advisers, many recruited from college campuses, certainly wield more influence than the men holding similar posts under Mr. Eisenhower.

Probably the most important scientist with access to the ear of Mr. Kennedy is **Dr. Jerome Wiesner,** formerly director of electronics research at MIT. As Special Assistant for Science and Technology, Dr. Wiesner had direct predecessors in Dr. James R. Killian and Dr. George Kistiakowsky. Knowledgeable scientists rate the three men about even in intellect, technical ability, and influence on the chief executive.

Mr. Eisenhower did not have counterparts to McGeorge Bundy, Walt Whitman Rostow and Henry A. Kissinger in his White House hierarchy. Bundy is Mr. Kennedy's

Special Assistant on National Security Matters and previously served as dean of the Harvard Faculty of Arts and Sciences. Rostow, who is officially Bundy's assistant but is actually considered on a par with him, is a former MIT professor of economic history. Kissinger is primarily a White House consultant on national security and retains his Harvard ties.

Outside the White House, there are five other men who have direct access to Mr. Kennedy on scientific and military matters.

Dr. Glenn T. Seaborg, chairman of the Atomic Energy Commission, is the first

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- **Electronic facilities for plotting aircraft positions.**

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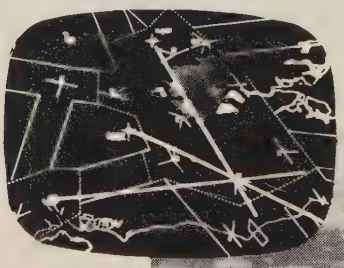

- **Assists identification of primary radar echoes of aircraft.**
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scientist to head the AEC. Acknowledged as one of the most brilliant nuclear physicists, Dr. Seaborg has immediate entree to the President's office to discuss anything from nuclear rockets for space propulsion to possible U.S. resumption of atomic tests. The AEC has always had at least one top scientist among its five members, but under General Eisenhower and Mr. Truman, the chairmanship was held by such men as Adm. Lewis Strauss, John A. McCone, Gordon Dean, and David Lilienthal. (Dr. Sumner T. Pike served as acting chairman for a few months in 1950.)

Paul Nitze, Assistant Defense Secretary for International Security Affairs has much closer ties with Mr. Kennedy than any of the men who held the same post under General Eisenhower, including Gordon Gray. Nitze, a long-time thinker and writer on military affairs, was formerly director of the State Department Policy Planning Staff.

Dr. Harold Brown, who replaced Dr. Herbert F. York as the Pentagon's Director of Research and Engineering is not as well known as York. But Brown, too, is a top-ranking scientist and can be expected to express himself to Mr. Kennedy on all subjects involving R&E, especially the anti-missile missile, V-STOL aircraft, and military space projects.

Two financial experts who constantly influence current Presidential decisions on military and scientific affairs are David E. Bell, the Budget Bureau director, and Charles J. Hitch, the Pentagon comptroller.

Both men have written extensively on military tactics and the influence of dollar ceilings on defense budgets, Bell as secretary of Harvard's Littauer Center for Public Administration and Hitch as a long-range planner with the USAF's Rand Corp.

The most interesting aspect of Mr. Kennedy's use of professorial thinkers to help shape scientific and defense policy is that he has been relying on the advice of Bundy, Nitze, Rostow, Kissinger, Seaborg, Bell, Hitch, and Wiesner far more than he has on professional military men.

While Gen. Lyman L. Lemnitzer can (and does) see the President regularly, most of the recommendations originate not with the chairman of the Joint Chiefs of Staff but with the civilian advisors. A direct parallel to this situation takes place once a week at the Pentagon.

Defense Secretary Robert S. McNamara meets with Hitch, Deputy Defense Secretary Roswell L. Gilpatric, Nitze, the Secretaries of the three Services (Elvis J. Stahr, Jr. of the Army, Eugene Zuckert of the AF and John B. Connally of the Navy) and a few other select civilians to mold defense plans. Their edicts are then transmitted to the military officers of the various services for action.

* * * * *

A shakeup in the Aerospace Industries Association will take place next January.

Gen. Orval R. Cook (USAF, Ret.), who has served as AIA's president since 1957 and been credited with doing a most effective liaison job for the industry with the Pentagon, NASA, and Congress, has decided to begin a second retirement starting the first of the year.

Cook has already notified the AIA board of governors (the heads of the major aerospace companies) of his intentions and the board is now seeking a replacement. One thing is reasonably certain: AIA, which has been headed by a retired general or admiral for many years, will pick its next chief from industry rather than the military.

Best bet to succeed Cook next year is August C. Esenwein, now a General Dynamics consultant and formerly executive v.p. for Convair-San Diego.

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management intelligence

HOUSE WILL ASK PRIME PRODUCERS TO JUSTIFY SURCHARGES ON SUBCONTRACTORS' PARTS

Industrial concerns selling to the various military services may soon have to explain the reasonableness of surcharges they make on items they buy from subcontractors. In the past, DOD has permitted a prime contractor to add a price mark-up on subcontractors' parts to cover managerial responsibilities.

With Rep. F. Edward Hebert's House Armed Services Investigations Subcommittee prodding the Pentagon, the Army, Navy, and Air Force are getting ready to ask prime producers to justify these surcharges, not only by amounts but also in concept.

Hebert's needling is also causing the Defense Department to plan revisions in the Armed Services Procurement Regulation (ASPR) so that contracting officers will have to justify the use of open contracts (with single-source producers) if they employ them instead of competitive bids.

WILL REQUIRE REAPPRAISAL

According to Thomas D. Morris, the Assistant Defense Secretary for Supply and Logistics, the ASPR revisions will require individual appraisal of reordered parts to determine whether they can be bought competitively. The new regulation, Morris says, "will require that a justification be established in any case where the order is placed under an open contract with a single source."

The DOD Assistant Secretary is extremely unhappy with present pricing techniques. "I am particularly concerned," he declares, "about the pricing of spare parts which we acquire from a prime contractor in situations where he, in turn, buys from a subcontractor. There is nothing intrinsically wrong with this method of procurement if the prime contractor performs essential functions of design and quality control which would be most difficult and costly and sometimes impossible to duplicate with government personnel. In such situations we must insure that the contractor is properly reimbursed for the work he actually performs. On the other hand, I am sure that we can improve our prices in some instances by going directly to the subcontractor."

Raytheon Corp. heads a four-company team selected by the Advanced Research Projects Agency to study the feasibility of knocking out enemy ICBMs without using nuclear weapons. The team will concentrate on ways to kill the enemy missile near the end of its flight. Study results will go to the Army as a guide to a possible successor or complementary weapon to Nike-Zeus.

The project will last about 30 months and cost about $15 million. The sum will cover $7 million for Raytheon and Lincoln Labs for radar, and $7 million for Hughes Aircraft studies of the interceptor vehicle. The remaining million will be cut into four pieces—Raytheon $300,000; Hughes $300,000; Boeing $300,000; and IBM $100,000 for system planning.

PENTAGON STUDYING WAYS TO REWARD EFFICIENT FIRMS

The Pentagon is studying ways to reward contractors for good performance and penalize those doing substandard work.

WILL ALLOW HIGHER PROFITS

Defense Secretary Robert S. McNamara indicates that efficient firms will be allowed higher profit margins, in the form of greater use of cost-reimbursable contracts (principally the cost-plus-fixed-fee type).

Military procurement has been tending in this direction for a decade. Fixed-price contracts have been declining steadily in dollar volume over the last 10 years while volume of costs-reimbursable awards rose from 13 per cent in '51 to 42 per cent in '60.

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Pentagon leaders believe many of the cost-control features in fixed-price contracts can and should be applied to the cost-reimbursement awards.

Only two contractors, General Dynamics and Lockheed, received more than $1 billion in new military orders during calendar '60. GD received six per cent of all DOD contracts, $1.294 billion, and Lockheed captured 5.2 per cent or $1.124 billion.

OTHERS IN THE TOP TEN

Others in the top ten included North American (4.4 per cent or $964.1 million); GE (4.2 per cent or $944.7 million); Boeing (four per cent or $867.1 million); United Aircraft (3.4 per cent or $739.1 million); Martin (3.3 per cent or $708.4 million); AT&T (2.3 per cent or $501.9 million); Hughes (two per cent or $437.6 million); and Raytheon (1.8 per cent or $374.2 million).

The Defense Department continues to place about three-fourths of all U. S. orders. In 1960, DOD obligated $16.147 billion, or 74.6 per cent of total U. S. orders. In calendar '58 DOD accounted for 74 per cent, and the figure dropped slightly to 73.2 per cent for calendar '59.

TWO COMPANIES WILL DO PRELIMINARY STUDIES OF SOLID-FUEL ROCKETS FOR NASA'S NOVA

DOD's allocation of $77 million in the fiscal '62 budget to develop solid-fuel rockets as a backup for NASA's Nova will result in the selection of two companies to do preliminary studies. One firm will ultimately be selected to build the solid-fuel booster.

Breakdown of the $77 million shows $15 million will be used by DOD for upper-stage development (which may actually be allocated to liquid fuels), $12 million will go for initial construction work (test stands, etc.) and the remaining $50 million will be applied to R&D and evaluation of solid-fuel first stages.

INDUSTRY PROPOSALS TO BE SOLICITED

Under present planning, DOD's portion of the man-on-the-moon-by-1970 project will cost $500 million for R&D and climb to $2 billion as fabrication stages involving major facilities are attained. The USAF's Aerospace Corp. will do initial studies on the upper stages, but proposals on this aspect of the lunar rocket will also be solicited from industry.

Despite the high costs of the DOD and NASA versions, Pentagon and NASA officials are reconciled to canceling one of the two approaches ultimately if both cannot be justified scientifically or militarily.

Meanwhile, the USAF has already let small study contracts for a whole new family of solid fuels which will give better performance than the fuels used in Polaris and Minuteman.

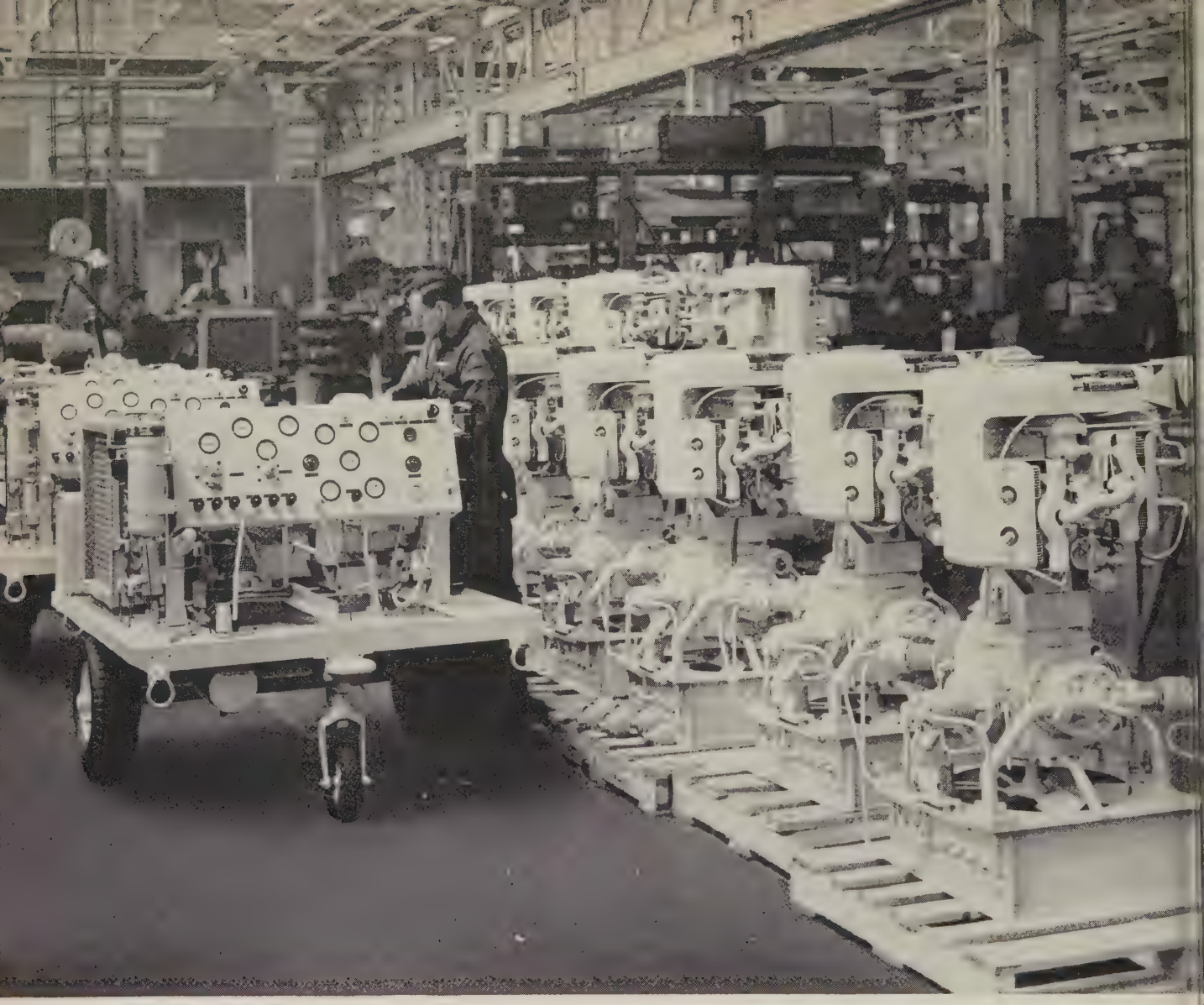
The Directorate of Rocket Propulsion at Edwards AFB, Calif., gave R&D contracts to five companies, including Aerojet-General ($560,000); Atlantic Research ($346,000); DuPont ($505,000); Thiokol-Elkton, Md. ($241,000) and United Technology ($175,000).

Military services expect to spend $850 million on research and development for space projects during the fiscal year which began July 1. This represents a sharp jump over the estimated $400 million for military space R&D in FY 1960 and nearly $500 million in FY 1961.

Emphasizing how the USAF is becoming the military space force, AF programs account for 87 per cent of the $850 million total. If USAF activities providing boosters and launch support to the Navy's Transit and Army's Advent satellites are included, the AF figure is about 91 per cent of the DOD total.

BENDIX WILL DEVELOP TYPHON WEAPON SYSTEM

Typhon weapon system, which will be ship-based and capable of knocking enemy planes and missiles out of the sky as well as for long-range bombardment of surface targets, has been assigned to Bendix Corp. for development.



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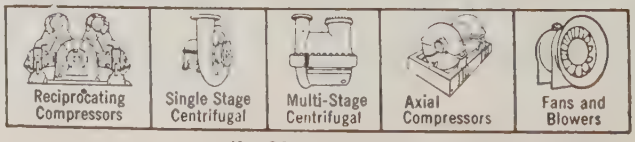

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The system will come in two versions (Long-Range Typhon and Medium-Range Typhon, originally designated Super Talos and Super Tartar) and is an outgrowth of the Johns Hopkins' Applied Physics Lab's Bumblebee project.

Nominally a surface-to-air weapon, Typhon will have greatly increased range over existing Navy ASMs.

Among the firms working with Bendix on the new missile will be McDonnell (airframe), General Dynamics/Pomona (guidance), Westinghouse-Baltimore (shipboard electronics). APL will have technical direction over the missile's R&D program and also over design and installation of the shipboard electronics.

PUSH DEVELOPMENT OF 800,000-LB ROCKET ENGINE

The Air Force and NASA are both expediting plans for development of an 800,000-lb rocket engine—about the size of the power plants now being used by Russia.

NASA picked four companies to make proposals on the Saturn S-II, the rocket's second stage, and hopes to award a contract to the winner by October. Firms selected are Aerojet-General, GD/Astronautics, Douglas, and North American.

The S-II will boost the Apollo three-man moon vehicle to escape velocity and also has potentialities for circumlunar flight. It will be powered by four Rocketdyne J2 engines that use liquid hydrogen/liquid oxygen for fuel.

Meanwhile, the USAF thinks the Titan II booster can be upgraded to provide 750,000-800,000 lb of thrust within 18 months by the use of a new high-energy liquid-fuel upper stage. The Titan II is already programed to boost Dyna-Soar and is also being considered as the launching vehicle for the Army's Advent communications satellite.

Contracts for 1141 aircraft, worth $1.8 billion, were in the hands of eight major Navy contractors on April 30. The planes are to be delivered over the next 2-3 years.

Grumman had a backlog of 113 planes, worth $391 million, and accounted for 22 per cent of the dollar total. McDonnell was set to deliver 144 planes, worth $362 million, and had 20 per cent.

The other contractors included North American (52 planes, $296 million, 16 per cent), Lockheed (71 planes, $268 million, 15 per cent), Douglas (301 planes, $153 million, nine per cent), Sikorsky (234 helicopters, $140 million, eight per cent), Chance Vought (156 planes, $133 million, seven per cent), and Kaman (70 helicopters, $53 million, three per cent).

The dollar figures cover only the cost of the airframes. Engines and other government-furnished equipment would sharply increase the prices.

Diversification efforts of several aerospace firms are apparent in the current Navy competition for a 275-300-ton hydrofoil vessel capable of speeds up to 75-85 kts. The Navy will not know whether it can pick one of the seven proposals until Congress passes on its hydrofoil development funds.

Companies which have made proposals include Boeing, Grumman in cooperation with Newport News Shipbuilding, Lockheed, Martin, Aerojet-General in cooperation with Todd Shipyards, General Dynamics' Electric Boat Division, and a combination of Bethlehem Steel and Gibbs & Cox, Inc.

The vessel planned by the Navy will be an anti-submarine warfare research vehicle using supercavitating foils that permit faster speeds than conventional hydrofoils.

The 300-tonner will be a major improvement over the 110-ton ASW hydrofoil Boeing is building. The Boeing vehicle will be capable of 45-50 knots. Grumman is also building a hydrofoil vessel using a GE J79 turbojet engine for propulsion.

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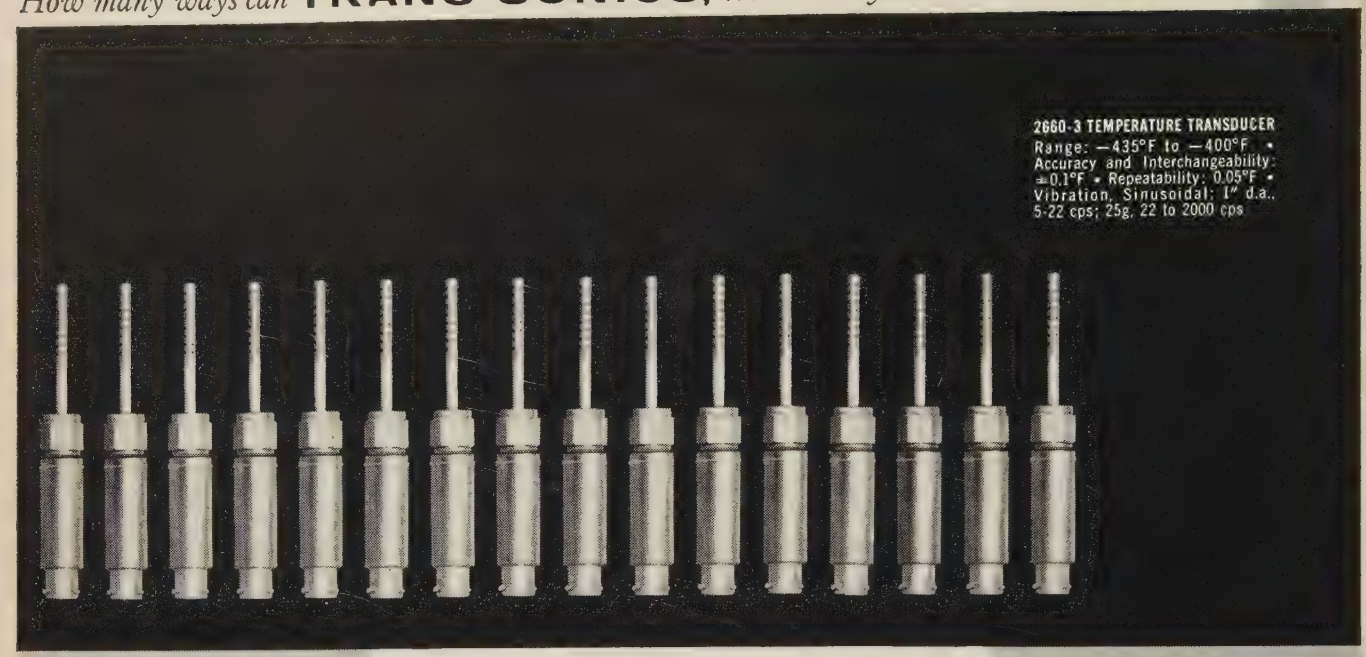
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INDUSTRY BRIEFING

NEW FACILITY WILL STUDY RADIO INTERFERENCE

A research program to analyze and control radio interference in this country and abroad will be carried out in a new facility set up by Armour Research Foundation of Illinois Institute of Technology.

Called the Electromagnetic Compatibility Analysis Facility, it will have temporary quarters at ARF, Chicago, until this fall. The facility then will be moved to its permanent location at the U.S. Naval Engineering Experiment Station, Annapolis, Md.

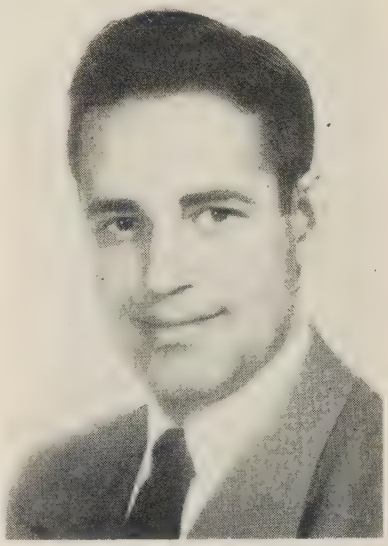
Head of technical operations is Stanley I. Cohn, who was assistant director, electronics research, ARF. He plans to have a staff of about 30 at work by the end of September. By the end of the first year some 100-110 people will be employed.

"With electronics being used more and more in the military," Mr. Cohn told SPACE/AERONAUTICS, "and with the advent of high-sensitivity receivers and high-powered transmitters, the mutual interference problem has become tougher. Equipment must be made to operate in these electromagnetic environments. The ECAF has been set up to analyze these compatibility problems and make recommendations for their solution."

Asked how this would be done, he answered, "Work will be primarily on large-scale problems which don't lend themselves to experimental solution. Therefore we'll use mathematical models—that is computer representations of the equipment characteristics and operational environment—to solve the problems."

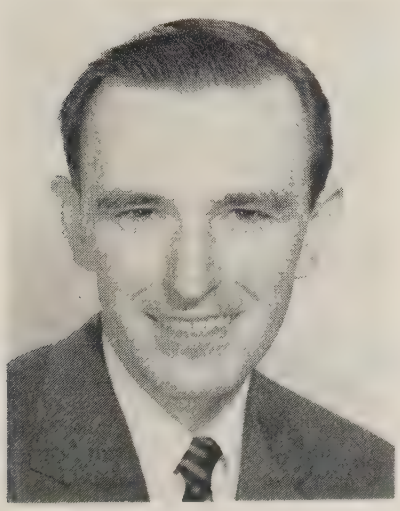
ARF received a $2 million contract from AF Systems Command's Electronic Systems Division for the research.

Cohn, who received his BS and MS in EE from Illinois Institute of Technology, has completed the course work for a Ph.D.



Stanley I. Cohn

DYNA-SOAR MOTOR WILL ALSO SERVE AS ESCAPE ROCKET



Frank A. McKinney

A multimillion-dollar subcontract for an acceleration rocket motor for Dyna-Soar was awarded to Thiokol Chemical Corp., Elkton Division, Elkton, Md., by Boeing.

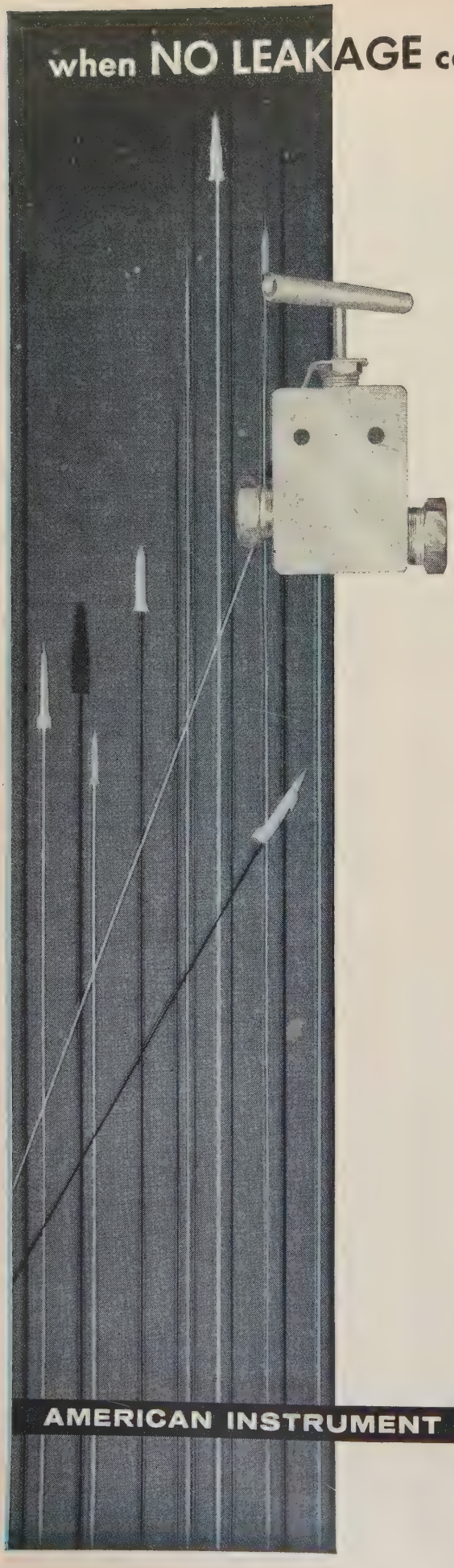
The motor will not only give added boost to the glider after the second stage of the vehicle's Titan booster has burned out, it also will serve as an escape rocket to hurl the glider and its pilot free of the booster in an emergency during launch.

The complete rocket engine will have a motor case, a thrust-vectoring device, a solid propellant and an ignition system.

Frank A. McKinney, Thiokol's program manager for the acceleration motor, sees the challenge as "primarily one of engineering and management, not of research." He points out that Boeing and the Air Force "have specified a propulsion system with performance requirements which, although stringent, are within the state of the art in solid propellant rocketry."

"The unique aspect of the Dyna-Soar motor," he told SPACE/AERONAUTICS, "is that it marries the high performance of the new solid motors for ballistic missiles like Minuteman with the ultra high reliability of man-rated rockets like the Mercury retros."

McKinney has more than eight years of experience in the design, development and program management of solid propellant propulsion systems. This experience was gained as a project officer in the USAF, and with Thiokol since 1955. He served 2½ years as solid rocket development project officer at WADC.



when NO LEAKAGE can be tolerated at gas pressures up to 20,000 p.s.i.

HERE'S YOUR VALVE!

Before introducing this new group of valves commercially, Aminco contracted with Wyle Labs, El Segundo, Cal. to subject prototype units to the rigid U.S. Air Force Evaluation Test Specifications for Propellant Loading (AMC, Ballistic Missiles Div.), and render a performance evaluation report. The test included internal- and external-leakage and proof cycle tests throughout 500 operating cycles. The Wyle program confirmed Aminco's pre-production tests . . . valves operated easily, and with COMPLETE FREEDOM FROM LEAKS, not only internally at the valve stem seat, but also around the valve packing.

The valve is well-suited for severe service and where absolute freedom from leakage, from excessive stem wear, and from packing deterioration are MUSTS. The valves embody a floating non-rotating stem tip which prevents the possibility of forcing the stem into the seat. Four models are available for applications ranging from the propellant loading of missiles to chemical and petrochemical plant service. Valves are easy to install . . . easy to operate. Bodies are constructed of 316-stainless steel; trim is of 400-series stainless steel except the packing gland nut which is of aluminum bronze.

IMMEDIATE DELIVERY

All four types are available from stock . . . all valves have 5/16 in. port openings, and are designed to accept 9/16 in. o.d. x 5/16 in. i.d. tubing. Dimensions common to all four styles: width, 2½ in.; body thickness, 1½ in. Packing is a compression-type, glass-filled fluoroplastic flat ring. All styles are furnished complete with necessary nuts and sleeves.

Order by Catalog Number:

44-1317 Two-way Thru Type Valve—As described and illustrated above. Height of valve body, 2-15/16 in.; over-all height, 5¾ in.

44-1337 Two-way Angle Type Valve—With port on one side and on bottom of valve body. Height of valve body, 3-3/16 in.; over-all height, 6 in.

44-1377 Three-way Offset Cross—As illustrated above but with an additional port on the bottom of valve body. Height of body, 3⅝ in.; over-all height, 6-7/16 in.

44-1357 Three-way Cross Type Valve—With a port on each side of valve body, located in line, and a third port on the bottom. Height of body, 3-3/16 in.; over-all height, 6 in.

AMINCO

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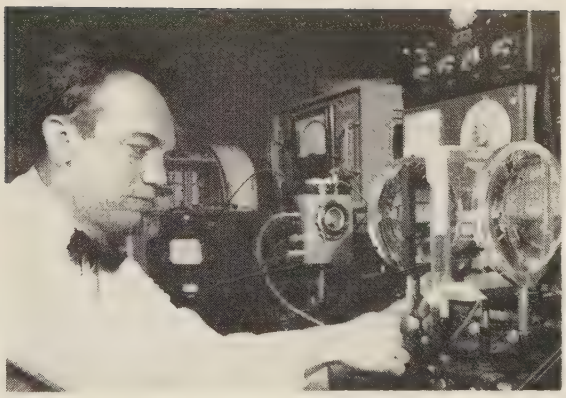
NEW BULLETIN

Complete description published in new bulletin 4075R-2 mailed upon request.

No. 22 on Reader Service Card

PHYSICIST TO STUDY ELECTRONIC CURRENTS



Dr. David Kahn

Dr. David Kahn, physicist at RIAS Div., The Martin Co., Baltimore, Md., has been given a contract to study electron currents in crystals.

Dr. Kahn, the principal investigator for the program supported by the AF Office of Scientific Research, will be assisted by Daniel Grabenstein.

The study of basic electronic concepts involves the behavior of electrical charge carriers in a type of crystal known as alkali-halide. Dr. Kahn's program is an attempt to measure accurately mobility and other characteristics of charge carriers over a wide range of temperatures—from room temperature to within a few degrees of absolute zero.

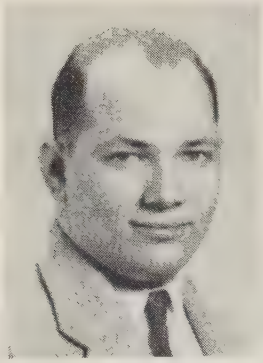
Techniques being developed for this research possibly may be applied to study organic semiconductors. Organic crystals promise to provide a less expensive material for use in electronic components.

In alkali-halides, Dr. Kahn explains, the electron deforms the crystal lattice locally by strong electrostatic attraction. This deformation may follow the electron as it moves through the crystal, like the bow wave of a ship, he said. Physicists call the electron and its deformation a "polaron."

It is the mobility of the polaron, Dr. Kahn added, that the study project seeks to determine.

Dr. Kahn joined the Martin RIAS staff in 1956. Before that he had done cryogenic research at the NASA-Lewis Lab and had studied for a year as an American Cancer Society Fellow at the Norsk Hydro's Institute for Cancer Research in Norway. He received his BS in Engineering Physics from the U. of Illinois and his MS and Ph.D. in Physics from the University of Chicago.

MAXSON TO DEVELOP NEW TACAN TRANSMITTERS



Kenneth Weinberg

AF Systems Command has awarded Maxson Electronics Corp., New York, N.Y., a contract to develop new lightweight Tacan ground transmitters.

Maxson's design for a transistorized portable transmitter offers savings in volume, weight and power demand over units now used at most military air traffic control centers throughout the world. It is expected that commercial jet transports also will adopt Tacan-type equipment in the future.

Maxson's transmitter development, says project engineer Kenneth Weinberg, will provide wider flexibility in the use of this advanced navaid where portability and power drain are significant factors.

Ken Weinberg received a B.E.E. in 1957, and M.E.E. in '60, both from Brooklyn Polytech, where he is also doing graduate work toward a D.E.E.

At Maxson Corp. he has worked on design and development of a partially transistorized display computer for the AN/APS-99 radar program. His responsibility included the design of all transistorized circuits in the range synchronization unit and display console, in addition to unit responsibility.

At the Airborne Instruments Laboratory Div. of Cutler-Hammer, he was in the design and development of reconnaissance systems and advanced recon techniques. He also designed transistorized video and digital circuits, a test generator for the AN/DLD-2, an analog peak amplitude selector for the AN/DLD-1, and a fractional binary divider for a study program. While at AIL, Weinberg published a study of polydigital receivers used to increase frequency resolution of reconnaissance receivers, and designed and developed a system for precision radar emitter location.

"Piggyback"

ride for a B-52... VICKERS® hydrostatic drives assist positive traction on icy airstrips

Ground handling the massive B-52 on icy airstrips demands positive, high-torque traction and ultra-fine control. The B-52 Towing Tug, developed and produced by Air Logistics Corporation, achieves this optimum performance utilizing Vickers' hydrostatic drives.

Driven to the B-52 under its own power, the vehicle locks onto the aircraft's landing gear. Inflated tubes form a friction-surface contact with the landing wheel hubs. The towing vehicle's driving wheels are then retracted and four Vickers' hydraulic motors (one per landing wheel) drive the B-52's wheels pushing the vehicle ahead of it. Maximum traction thus is obtained utilizing the aircraft's own weight.

The Vickers' hydrostatic drive system affords these advantages: • four wheel, reversible drive for the aircraft's wheels • selective, variable speeds and torques • fluid differential action under normal driving conditions to prevent "scuffing" • automatic, fluid-power application of torque to those wheels having traction when one or more are slipping on a "slick spot" • dynamic braking • remote control up to 100'. The Vickers' hydraulic system also provides power for steering the aircraft and for the friction tubes.

For the G.S.E. designer, Vickers' hydrostatic drives provide many unique advantages. Let us show you how these advantages can be applied to your project to meet its most exacting requirements. When you are in the early design phase, our prompt assistance can reduce your development time and costs, improve simplicity and reliability.

For immediate information call Waterbury, Connecticut, PLaza 6-3684 (TWX: WBY 160).

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MO-231

No. 23 on Reader Service Card

SECOND MERCURY FLIGHT SUCCESSFUL, CAPSULE LOST IN 2800 FATHOMS

The second Mercury flight, with AF Capt. Virgil I. Grissom aboard, was successfully completed at a point off Bahama Island, 305 mi downrange from Cape Canaveral. The capsule reached an altitude of 118 mi and a speed of 5,280 mph (uncorrected figures). The Redstone booster lifted off at 8:20 a.m., July 21, after an hour-long hold because of cloud formations. The mission had been scrubbed three days earlier because of clouds that would have interfered with optical tracking.

The fifteen-minute flight went according to program, with separation and escape-tower jettison going off smoothly. Voice communication was interrupted for a short period during re-entry.

After landing, the escape hatch came off and the capsule shipped water. Grissom had to leave the capsule and was fished out by a helicopter. The capsule itself was too heavy with seawater for a second copter to lift, and it sank in 2,800 fathoms. Only the photographic record was lost, however.

Titan II's thrust is 430,000 lb for the first stage and 100,000 is for the second. The ICBM has a takeoff weight of 150 tons, a height of 102 ft, and a range of over 6300 miles. The first stage is 70 ft high.

SIMULATOR WILL TEST CONTROL SYSTEMS

Chance-Vought developed an "automatic-controls evaluation simulator" (ACES) that duplicates spacecraft control problems as closely as it can be done on earth, it is claimed. ACES is a 12-ft-long, 1350-16 aluminum-tubing platform balanced on pressurized single point mounting. The latter is a 4.5-in. steel ball floated on a 120-psi column of nitrogen.

The simulator will be used to develop and test reaction jets and other control systems and to train pilots in some of the control problems expected in space. It will also measure the effects on a spacecraft of erecting antennas and deploying solar arrays of ejecting decoys and interceptors, and of launching auxiliary vehicles.

The simulator can move 35 deg from vertical in pitch and roll and 360 deg in yaw (except when it is remotely controlled). It has eight nitrogen reaction jets for control—four for roll and two for each of the other axes. Tanks filled with 3000-psi nitrogen are mounted on the platform.

A side controller and foot pedals are used for piloted operation. ACES programs for control-systems development include studies of electronic circuitry, valves, sensors, trackers, fuel and power consumption, interaxis coupling, and control system de-saturation. Computer facilities can be added for evaluation of re-entry and orbital-transfer conditions.

MIDAS III GOES INTO RECORD POLAR ORBIT

Midas III was placed in a record 1850-mile-high circular polar orbit two days after its booster had failed to sustain ignition after initial firing and stayed (undamaged) on its pad at Point Arguello, Calif. The Atlas booster functioned perfectly on the second try, and the Agena B second stage, which carried the payload in its nose and became the satellite, was restarted at the apogee of a first, highly elliptical orbit to place it in the final course.

The *mi*ssile *d*efense *a*larm *s*ystem satellite is designed to detect missile firings by sensing the heat of rocket exhausts with its infrared instrumentation. It is intended to

TACTICAL Combat Surveillance

The modern Army's new skills and advanced weaponry have created new requirements in combat surveillance—new needs for accurate, invulnerable, detection-free and above all high-speed intelligence gathering and transmission under fast-changing combat conditions.

Target location, damage assessment and other surveillance missions demand the most advanced techniques in guidance, data links, and data processing if they are to give the field commander the intelligence he needs in time for him to put it to tactical purpose.

Sperry is meeting difficult assignments of this nature in many defense areas now. No organization has more experience—in greater depth—in guidance, control and complete avionic systems for surveillance drones or manned aircraft. And with the breadth of its experience in associated technologies, Sperry is ready *now* to meet the toughest objectives in combat surveillance—*tactical* combat surveillance for today and the immediate future.

SPERRY

SPERRY PHOENIX COMPANY, DIVISION OF SPERRY RAND CORPORATION, PHOENIX, ARIZONA

No. 24 on Reader Service Card

double the fifteen minutes' advance notice of a missile attack now expected of BMEWS. The system, for which Lockheed is the prime contractor, will have 12-15 satellites in orbit when it is fully operational.

Several new Red military planes, some with no Western counterparts, were shown off in Aviation Day flyby at Tushino Airfield outside Moscow. The Bounder, the Soviets' newest heavy bomber, has a delta wing with two very large jet pods beneath it and a pair of smaller wing-tip jets. In general configuration, it is similar to the B-58 (with the exception of fuselage extension aft of the wing), but in size it appears to be at least in the B-52 class. It may even be as heavy as the B-36.
Ten medium bombers of a new design with delta wings and two tail-mounted engines also took part in the display. Other aircraft observed at the show included light bombers and interceptors, jet seaplanes, and large rotary-wing craft. One fighter carried a liquid-propellant rocket, which showed off on a vertical climb.

TURBOFAN 707-320B FEATURES MORE RANGE AND PAYLOAD

Boeing's turbofan 707-320B Intercontinental will have 20 per cent more range than comparable configuration of the turbojet 707 or carry 10 tons more. The 735-320B cargo version will have a 3200-mile non-stop range with a 40-ton payload at the lowest available ton-mile cost, says Boeing. The passenger version will carry 186 in all-tourist seating. Both versions are powered by P&WA JT3D-3(W)s.

TIROS III WILL TRANSMIT CLOUD-COVER PICTURES, MEASURE RE-RADIATION OF SOLAR ENERGY

Tiros III was launched from Cape Canaveral, Fla., on the same day as the Midas III. The 285-lb NASA weather observation satellite was put into a nearly circular orbit—apogee, 505 miles; perigee, 460-miles—at a 48-deg inclination by its Thor-Delta booster.

TWO WIDE-ANGLE TV SCANNERS

The latest Tiros has two wide-angle-lense television scanners, instead of one wide- and one narrow-angle scanner as did the Tiros I and II. Like its two predecessors, Tiros III has a magnetic-tape storage system that can record up to 32 images, which are transmitted on command to ground stations at Wallops Island, Va., or San Nicolas Island, off southern California.

The launching of the Tiros III was timed for the beginning of the hurricane season. The cloud-cover pictures the satellite will send back are expetced to provide valuable information on the origin, development, and movement of hurricanes. In addition to its TV cameras, the Tiros carries infrared sensors to measure how much of the sun's energy that is absorbed by the earth and its atmosphere is re-radiated.

The Tiros III was developed by RCA's Astro-Electronics Division at Princeton, N.J. Its power is supplied by solar-cells. Nickel-cadmium batteries are used for storage. The expected useful life of the satellite is three months, though Tiros II, launched in November '60 with the same life expectations, is still transmitting.

With the successful launching of Midas III and Tiros III, the total of U.S. satellites in earth orbit rose to 28. Two others are in orbit around the sun, and 17 more have re-entered the atmosphere and burned up. The USSR has only one satellite still in an earth orbit (out of 12 it has launched) and two in solar orbits. One Russian probe impacted the moon. The recent Venus probe will presumably go into a solar orbit. There is a remote possibility that it might be captured by the gravitational field of Venus and go into orbit around the planet. As all contact with it has been lost, it is highly unlikely that we'll ever determine its final orbit.

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NEW VAPOR DETECTOR

Warns instantly of toxic or explosive vapor danger

If you are concerned with missiles or missile fuel handling, consider these features of General Electric's Automatic Vapor Detector safety device:

IT IS EXTREMELY SENSITIVE. As minute an amount as one half part per million of a toxic or explosive vapor can be detected.

IT IS HIGHLY FLEXIBLE. Detector can be easily modified to detect any one of 15 vapors, including hydrocarbons and halogens, and the list is growing. Many areas can be monitored simultaneously.

WARNING IS ALMOST INSTANTANEOUS. The sampling rate of G.E.'s Vapor Detector is approximately five times a second.

EQUIPMENT IS SIMPLE. Only a pump, sampling unit and alarm unit are required. All functions are fully automatic.

This vapor detector has already been selected by the Navy for a shipborne application, and can be tailored for any application where missiles or missile fuels are handled, stored or tested.

Here is another example of LMED leadership in aero/space electronics.

150-01

GENERAL ELECTRIC

Light Military Electronics Department

Utica, New York

No. 25 on Reader Service Card

The 16-station Mercury tracking network will be checked by a small satellite simulating an orbital Mercury flight before the actual manned mission is launched. The 100-lb Mercury-Scout I, with a payload consisting of a duplicate set of Mercury transmitting and receiving equipment, will be launched late this summer from Cape Canaveral. The booster will be a four-stage, solid-propellant Scout.

DYNAPAK PNEUMATIC PRESS SUCCESSFULLY COMPLETES HIGH-ENERGY-RATE HOT-FORGING TESTS

High-energy-rate, hot-forging tests were successfully carried out by American Brake Shoe at its Mahwah, N.J., Research Center with a General-Dynamics Dynapak pneumatic forging press. The machine is the largest of its kind to date and has a maximum energy of 431,000 ft-lb, a 105-second cycle, a 250-1500-ips ram velocity, and a 15-in. stroke. The firing pressure is 2000 psi, there is a one-second dwell time, and the maximum die diameter is 22.5 in. Tests so far have used only 35,000 ft-lb of the available energy.

FORMS PART IN SINGLE PASS

Intricately formed parts have been made from aircraft-quality 4130 steel, tough-pitch copper, and copper powder compacts. A cone-shaped piston cap for a hydraulic landing-gear strut was formed from a cylindrical 2x2-in. billet of 4130. The billet was first heated to 2150 deg F in a molten-salt bath. Die sections were lubricated with a graphite and water mixture to prevent sticking, and the part was formed in a single pass. Conventional methods would have required at least four press strokes and a cold trim press operation. The formed part has a wall thickness of 0.180 in. (held to ±0.005 in.) with a concentricity of ±0.010 in. The surface finish is better than that obtained with normal forging operations, according to company metallurgists.

The same tooling was used to form a part from a copper powder compact. A 2.1-lb billet with a density of 65 per cent was sprayed with a water-soluble phosphate lubricant and heated to 1450 deg F in a furnace before forming. The forged part had a minimum density of 98 per cent with almost no metal loss and excellent surface finish and grain flow.

The tough-pitch copper part is normally machined from solid bar stock. Forged from a 9.1-lb billet, it weighed 8.9 lb, had a 1¼-in.-diameter, 2½-in.-deep hole.

Neutrino astronomy can yield important astrophysical data, according to a report by two Hungarian researchers that has been translated by the U.S. Joint Publications Research Service. Gyorgy Marx and Nora Menyhard point out that neutrino radiation emitted by heavenly bodies is one of the most intensive forms of radiation. Detection of cosmic radiation from beyond the solar system, they say, requires an accuracy of measurement many times greater than is possible today. Detection of neutrino radiation from the sun, however, calls for an increase in sensitivity of only one or two orders of magnitude. This, they state, can probably be attained in a year or two.

SUPER VC10 SEATS 180

Super VC10 version of Vickers-Armstrongs' four-tail jet transport, which has been ordered by BOAC, is 164 in. longer than the basic VC10 and can seat 180 passengers instead of 150. Freight compartments in the bottom of the fuselage are increased in size from 1350 to 1950 cu ft. and the maximum payload is up to 45,000 lb from 38,000. Both planes can cross the North Atlantic non-stop in either direction. Maximum take off weight is 322,000 lb. The powerplants are Rolls-Royce Conways with a static thrust of 22,500 lb each.

THREE SATELLITES ORBITED IN TRANSIT IV-A LAUNCHING

Transit IV-A launching scored a couple of firsts: It was the first time three satellites were orbited with one booster and the first time atomic power was used in space.

MINIATURIZED

PRESSURE REGULATORS

Grove Mity-Mite®... light, compact, accurate for reducing, relief and back pressure control. Grove Mity-Mite regulators are materially smaller than conventional regulators of comparable capacities. They are available for pressure reduction, combination reduction and relief, and back pressure services. Mity-Mites utilize the same proven gas dome-loaded principle of Grove Powreactor® Regulators—a design that has set engineering standards for every pressure regulator used in aerospace today! Mity-Mites may be supplied in externally or internally loaded models in dural or 18-8 (type 303) stainless, from ¼″ to 1″, with inlet pressures to 10,000# psi; outlet pressures to 6,000# psi. For complete engineering data, send for Bulletin #940-H.

GROVE REGULATORS

GROVE VALVE AND REGULATOR COMPANY

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Another Way Grove Sets Regulator Standards for Others to Follow

No. 26 on Reader Service Card

The three satellites are the Transit itself, the third in the Navy's navigation satellite program; the Greb III, a Naval Research Lab project for studying X-ray radiation from the sun and its effects; and the Injun, designed by Dr. James Van Allen to study the Van Allen radiation belt's relationship to the aurora borealis.

The Transit IV-A has a conventional solar-cell-battery power supply as well as a small Snap unit producing about 2½ W from the heat of the radioactive decay of plutonium 238 acting on thermoelectric elements. The nuclear power supply is used for one of the satellite's two transmitters.

The two piggyback satellites separated from Transit, but not from each other. All three, however, sent back signals.

The Mercury capsule for the second U.S. astronaut's flight is a considerably modified version of the Freedom 7 that carried Cdr. Alan Shepard into a ballistic trajectory. A large observation window replaced the two small viewing ports found inadequate by Shepard, and a more advanced type of manual control is used in the rate command attitude control system. The second U.S. astronaut also will have fewer tasks to perform than did Shepard (or rather will have performed them; if this flight comes off as scheduled shortly after press time).

SILICONE LUBES PROVED SUPERIOR

Silicone lubricating and hydraulic fluids have shown long-term stability from —140 to more than 700 deg F, according to GE researchers. Previously they could be used only within limits from —100 to 700 deg F.

G-300 silicone grease and Versilube F-50 fluid lubricant proved superior to comparable lubes under the simulated space conditions of a 10^{-7}-mm vacuum. They showed evaporative losses of only five per cent, as against up to 50 per cent for other types of petroleum and synthetic lubricants, according to GE.

GE's Missile & Space Vehicle Department also tested a form of silicone rubber to 9000 deg F in a supersonic electric-arc wind tunnel for six minutes. Seventy per cent of the material remained flexible and undamaged under a charred crust that formed on the surface. Its effective resistance to ablation was seven times better than that of a material now used on missile nose cones. Other silicone materials, including insulations, were tested for resistance to corona discharge, radiation exposure, high vacuum, and other space phenomena.

BELIEVES MAGNETIC FIELD GOVERNS PLANETARY MOTION

The solar magnetic field causes the earth's rotation, argues Yugoslav scientist Ilija Deckovski, who has been studying what he calls "a so-far unknown phenomenon for the transformation of the vibrational energy of a fluctuating magnetic field into a direct and simultaneous rotational and revolving movement of the earth and the other planets around the sun. He bases his claim on studies of the behavior of a magnetized ball that begins to rotate and revolve on a smooth plane (e.g., a sheet of glass) when the whole assembly is held in a fluctuating magnetic field. He states that it is this principle on which a vibrational micromotor of his design works when placed in a vibrating magnetic field and that it has nothing in common with a rotating magnetic field.

SEES EARTH AS VIBRATION MOTOR

Deckovski further believes that this principle governs the movements of the planets around the sun and of particles around the atomic nucleus. The revolutionary circle of the magnetized ball departs somewhat from a true circle, he states, and the rate of rotation and revolution depends on the radial distance of the ball from the source of vibration. The earth, Deckovski says, is a big vibration motor whose rotor is represented by the fluid core, the hot magma, while the crust of the earth is the bearing. The magnetized core, under the influence of the strongly fluctuating poles of the sun, exerts a vibrational force on the earth's crust. According to the principles of a vibration motor, these impacts impart a rotational momentum and cause the earth to rotate. At the same time, Deckovski says, the sun's poles cause the revolutionary movement of earth around sun. Satellite tests, in which his vibration motor could be placed beyond the influence of the earth's magnetic fields, could prove his hypothesis, he concludes.

Separate motors are attached to each wheel of this 150-ton LeTourneau Jungle Destroyer with BERYLCO beryllium copper bolts.

On land, under the sea, and in space...

BERYLCO® BREAKS DESIGN BARRIERS

Extraordinary properties and performance characteristics of beryllium metal and its alloys have enabled BERYLCO to assist designers in practically every industry. Creating new products or re-designing existing products, you'll find, as many others have, that checking into the possibilities of BERYLCO metals and alloys is a wise move.

Key parts like bolts for the individually-powered wheels of LeTourneau equipment, components in guidance systems for missiles like the Atlas, and heavy-duty springs in submarines provide higher part performance because of properties found only in beryllium alloys. Good conductivity, formability, high fatigue life, corrosion resistance, and heat resistance are a few of the advantages found in BERYLCO alloys that offer the solution to many material problems.

Write for latest technical information on how BERYLCO beryllium alloys can help you break design barriers. BERYLCO specialists have for over 30 years been helping to turn design possibilities into performance realities.

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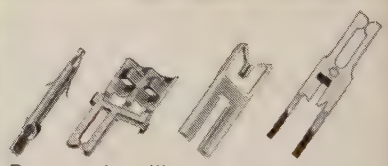

BERYLCO beryllium copper contacts assure reliability in guidance system circuitry of Atlas missiles.

General Dynamics Ph

BERYLCO beryllium copper springs helped solve a design and performance problem in modern submarines.

CALENDAR

AUGUST

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		1	2	3	4	5
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SEPTEMBER

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OCTOBER

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22	23	24	25	26	27	28
29	30	31				

Aug. 15-17 Cryogenic Engineering Conference, U. of Michigan, Ann Arbor, Mich.

Aug. 16-18 International Hypersonics Conference, American Rocket Society, Massachusetts Institute of Technology, Cambridge, Mass.

Aug. 19-24 Institute of the Aerospace Sciences, Naval Aviation Meeting, San Diego, Calif.

Aug. 23-25 Fourth Biennial Gas Dynamics Symposium, ARS, MIT, Cambridge, Mass.

Aug. 28-Sept. 1 Fifth International Conference on Ionization Phenomena in Gases, Plasma Physics Research Branch, ARL, Wright-Patterson AFB, Munich, Germany

Aug. 28-Sept. 1 Symposium on Chemical Physics of Non-Metallic Crystals, AEC, National Science Foundation, Northwestern U., and AFOSR/Solid State Sciences Div., Northwestern U., Evanston, Ill.

Aug. 30-Sept. 1 Third Annual Semiconductor Conference, American Institute of Mining, Metallurgical and Petroleum Engineers, Ambassador Hotel, Los Angeles, Calif.

Sept. 4-14 Eighth Anglo-American Aeronautical Conference. Royal Aeronautical Society and Institute of the Aerospace Sciences, London, England.

Sept. 20-24 National Convention and Aerospace Panorama, Air Force Assn., Philadelphia, Pa.

Oct. 2-7 12th International Astronautical Congress, Washington, D.C.

Oct. 9-15 16th Annual Meeting & Space Flight Report to the Nation, ARS, Coliseum, New York, N. Y.

Oct. 23-24 Joint Meeting, Canadian Aeronautical Institute/Institute of the Aerospace Sciences, Ottawa, Canada

Oct. 23-27 43rd National Metal Exposition & Congress, Convention & Exhibits Building, Detroit, Mich.

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TYPICAL MULTI-CHANNEL MEMORY UNIT *
Ken Smith

MARQUARDT MULTI-CHANNEL MEMORY SYSTEM

allows realistic simulation of longer range and lower altitude tactical training missions

Based on a major technical breakthrough in information storage, Marquardt's new bombardier/navigator radar trainer system provides outstanding simulation characteristics. The flexibility and capacity of the Multi-Channel Memory—a high density storage medium—make possible realistic simulation systems capable of meeting the advancing speed, range, and altitude requirements of aero-space technology.

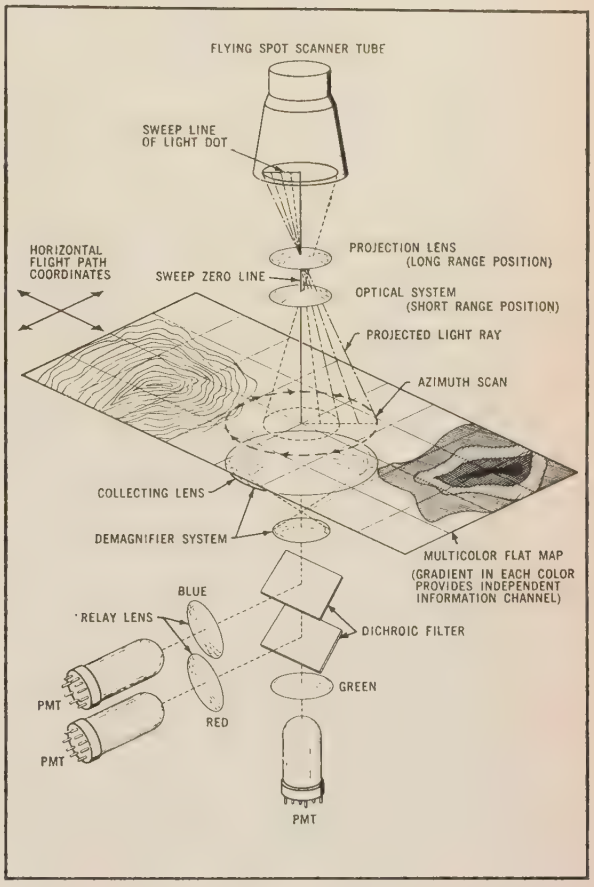
The Multi-Channel Memory uses a three color film transparency in which terrain information and radar reflectivity data are stored on a map scale ratio of three million to one, or better. A highly detailed terrain map representing a land mass area 2,000 miles by 3,000 miles can be permanently stored on a slide only 48 inches by 72 inches. Because the map transparency is flat and terrain elevations are reproduced electro-optically, there are no physical limitations to its use. The system is particularly well suited for very low altitude simulation.

Information in the Multi-Channel Memory System is coded as varying densities of the three colors of the film transparency. During operation the transparent map is scanned by a flying spot scanner. After passing through the film the light is separated into various channels by filters and mirrors and converted to electronic signals by photomultiplier tubes. The light intensity in each channel is dependent upon the absorption of the corresponding color dye in the film. The signals are then processed by a high speed computer and displayed on the face of the PPI (plan-position-indicator) radar display.

Because of its flexibility and large storage capacity, the Multi-Channel Memory System has application to missile and space training problems, information storage and retrieval, automatic language translation, advanced command and control systems, and similar computer uses.

The bombardier/navigator training system mentioned above, and now being developed for the Air Force, is the result of more than ten years of experience in the development and manufacture of trainers and simulators. Marquardt has successfully produced, installed and maintained world-wide—on time and at low cost—bombing and navigation trainers, gunnery radar trainers, AEW/CIC trainers, special purpose trainers, and ground control intercept trainers. For information concerning Marquardt's training and simulation systems capabilities, contact William Lord, Pomona Division, The Marquardt Corporation, Pomona, California.

Scientists and engineers experienced in the fields of simulation and training systems are invited to investigate exceptional career opportunities with The Marquardt Corporation. All qualified applicants will receive consideration regardless of race, creed, color, or national origin.



DATA EXTRACTION FROM COLOR TRANSPARENCY
The principle of land mass simulation storage and readout is shown above. Terrain elevation and radar reflectivity are coded as varying densities of the three colors of a color film transparency. As the light source simulates airborne radar scan, signals are generated by the photomultipliers to provide information necessary to simulate a radar presentation.

★ MULTI-CHANNEL MEMORY UNIT
Shown on the opposite page is the heart of the Multi-Channel Memory System — a three color film transparency. Each color provides a permanent and separate information channel in perfect register at any point no matter how large the map.

THE Marquardt CORPORATION

CORPORATE OFFICES, VAN NUYS, CALIFORNIA

ASTRO ◆ OGDEN DIVISION
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◆ POWER SYSTEMS DIVISION

Pert and Pep:

useful tools or timewasters?

YOUR FIRST LOOK at a typical Pert (*p*rogram *e*valuation and *r*eview *t*echnique) "network" with its mess of circles, arrows, lines, and cabalistic jottings sprawling across a large sheet of paper raises some doubts. This is a "tool"?

Most engineers are skeptical, to say the least, when Pert is first explained to them. They are no more impressed by the second explanation, either.

The old bar chart showing project progress is a marvel of simplicity and usefulness alongside a Pert network display. Why complicate matters?

Nonetheless, since the Navy started Pert for the Polaris program almost four years ago, and the Air Force started its similar Pep (*p*rogram *e*valuation *p*rocedures) in August 1960, aerospace companies have been picking up these systems as new methods to improve project management control. Just the USAF programs using Pert make an impressive list: Skybolt, Minuteman, Dyna-Soar, Bomarc, C-141, B-70, F-105, Sage, TAC & W (Sage adaptation), the SAC communications system, Midas, and Samos.

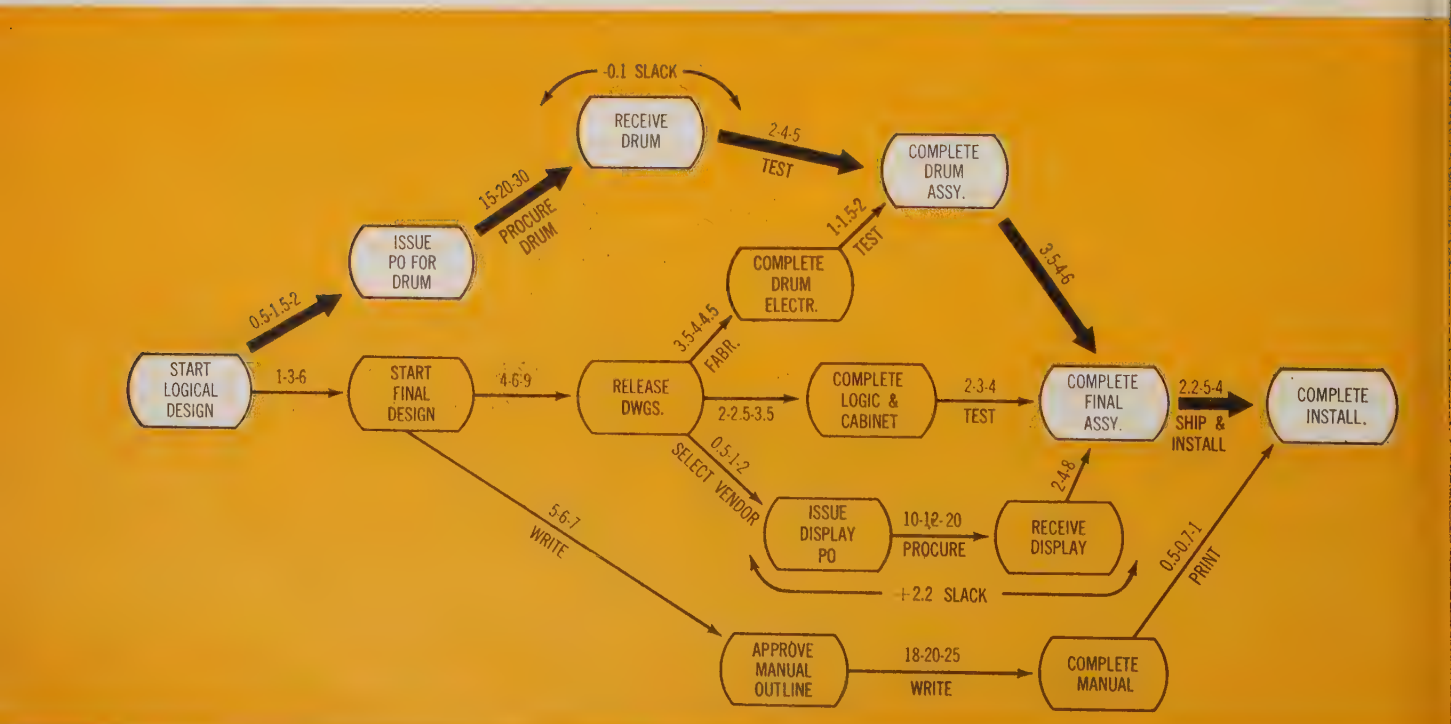
Pert has even brought the three services together—the Navy, Air Force and Army are coordinating on Pert to standardize the semantics of the technique. And now NASA also is adopting Pert for its space programs.

With all of the aerospace industry's biggest customers sold on Pert, the industry is in a situation where it can't beat 'em but has to join 'em. But that doesn't answer the question whether Pert is really a useful tool or only a particularly elaborate piece of wasteful red tape.

To begin with, why Pert *and* Pep? Maj. Harry I. Sparrow, assistant chief of the Management Procedures Division at the Air Force Systems Command (AFCS) readily admits that "the two systems are the same in basic philosophy and objectives."

They are management control and planning systems for defining and integrating what must be done to reach program objectives on time. The difference between Pert and Pep, Sparrow told SPACE/AERONAUTICS, is that the Air Force lets the primes use their own computers to process the time estimate data, while the Navy uses its Nord computer. "However," Sparrow said, "the Navy is thinking of following Air Force policy in the processing of time data."

The basic idea behind Pert and Pep is simple: If all the activities that must be done to complete a



by Randolph Hawthorne, Editor

Sponsored respectively by the Navy and the Air Force, the new Pert and Pep program evaluation techniques have been in use for several years. Both are based on the idea of charting a program as an interlocking network of activities that will clearly show the program's most critical areas.

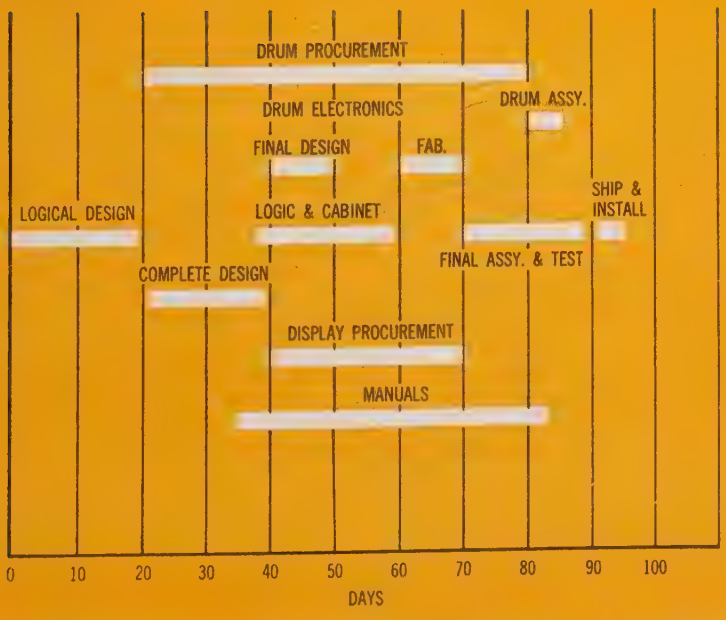
The military services are solidly in back of Pert, which soon will also be used by NASA. Industry managers who have been using Pert or one of its modifications tend to agree with the military—they call Pert a breakthrough in management control and say that it is much more helpful than were previous program control techniques. They point out, however, that Pert is not necessarily a scheduling tool and, above all, that it will work only when the engineer down the line is convinced of its benefits to him.

project are known, if the time needed for each of these activities is accurately estimated, and if these activities are then linked together in the form of a network to show the order in which they should be performed, then you can see (literally) which activities will be critical—because they determine how fast the rest of the project can be done.

Pert from the beginning focuses management's attention on the areas for which program control is most important. In case one of the critical activities starts slipping, Pert also shows how tradeoffs in time, resources, or performance might get the program back on schedule.

Pert, it's proponents say, does what bar charting does and then some. Like the bar chart, it identifies the main events, establishes a sequence of operations, and shows a time schedule. But Pert also shows the interdependence of activities and so identifies the critical areas, permits evaluation of slides without extensive reviews of planning, and offers a more accurate basis for computing the likelihood of meeting schedules.

Boeing, a pioneer in the application of Pert, points out that, "in any major project, 10-20 per cent of the activities . . . control the time required for the entire



TYPICAL PERT network, set up by Aeronutronic (far left) shows interrelationships of events (circles) and activities (arrows). Heavy arrows show the "critical path" of activities that determine the speed with which the rest of the program is accomplished. Engineers make three time estimates for each activity: optimistic, most likely, pessimistic. "Slack" times are shown as plus or minus values. Near left: The same program shown on standard bar chart.

project." These decisive activities form the "critical path"—a concept similar to the "master flows" and "life-lines" commonly used in production programs.

To find the critical path of a program, Boeing explains, the program's schedule plan is turned into a sequentially arranged network of circles showing events, and lines connecting the events to show activities. (Sometimes a line doesn't show an activity but merely that one event must precede another.) Once time estimates are assigned to all activities, Boeing computes the critical path. It also identifies activities that have slack and which may be extended without affecting program schedules.

Large networks done in sections

Small networks, consisting of a few hundred events, can be computed manually, Boeing says. For larger networks of up to 2500 events and 500 activities, the company has developed an IBM 704 program. Still larger networks can be processed by running them through the computer in sections and consolidating the sections manually.

Boeing has also checked out a program for the IBM 709, which turned out to be five times faster—it computed the critical path for 685 events and 1050 activities in 15 seconds, as against 75 seconds on the 704.

Boeing then went to work to improve the 709 program. In addition, it added manpower estimates to its Pert networks, which will provide the data for control of resource allocation.

Pert isn't just a tool for management, points out Aeronutronic's Program Analysis Department. It is an important tool for everyone.

With Pert, "a scientist can see his role better as it relates to the entire project," Tuttle says. "He also [now] analyzes his . . . tasks quite early in the project —preferably during proposal preparation."

For the "schedule visibility system" (svs), Aeronutronic's adaptation of Pert, technicians, engineers, and scientists make three time estimates for each activity: optimistic, most likely, and pessimistic. These estimates are turned over to the svs administrator, who has previously sequenced tasks after consulting with project engineers. All his information is then put on punch cards, and an evaluation is run on an IBM 709. The evaluation is made available to project management in the form of the program network. The network can be updated as often as once a week, Aeronutronic says, even though most projects need changes only twice a month.

SVS already has been used for the Decoy program and for several proposals. It is now being applied to the Shillelagh missile program.

GE was first introduced to Pert by the Navy early in '59. Previously it had used a variety of standard management methods like planning by milestones and measurement by the adaptation of line of balance to percentage of completion used.

"We soon saw that these techniques were not nearly as close to the actual theory of the business as was Pert," states an official of GE's Light Military Electronics Department. "Here at last was a technique which permitted management to use actual engineering experience in setting and meeting realistic programs."

GE's experience has taught it that the working engineer must be convinced that Pert is all that it is said to be—a tool that lets him plan and measure his efforts as they relate to the whole program. If the engineer's suspicion that Pert is merely a management reporting scheme is not dispelled at once, Pert cannot succeed, GE says.

Although industry managers think that Pert is indeed all it's said to be, they don't think it is the last word in systems management. For example, Boeing's director of reliability, Dr. Leslie Ball, believes it would be "extremely advisable" to include cost and reliability data in program networks.

Computer capacity is limitation

Boeing also points out that an obvious limitation lies in computer capacity. Most existing computer programs will handle up to about 5000 activities. Without too much trouble, this could be expanded to around 10,000 activities, but beyond that computer time and cost go up significantly, Boeing told Space/Aeronautics. This limitation may be overcome by the development of new computers, but not the basic one that the processing of a large amount of data takes a lot of clerical labor and increases the likelihood of error.

Even more serious, Boeing adds, are the problems of summarizing and integrating networks. No methods have been developed for automatic summarizing of very large networks, and the methods for integrating separate networks are cumbersome.

Boeing's experience indicates that, on large programs Pert is best used for planning and control. On small, simple programs it may also be used as a scheduling tool. In the Dyna-Soar program, Pert networks at first were attempted at a high level of detail, so that Pert might be used for scheduling. Because of the large number of activities, however, this approach didn't work out. Now a broad program network is being developed to be used in program planning and control only. This network will be expanded to cover more detail as the Pert techniques in this application are developed further. Still and all, Boeing believes that "Pert provides the most promising vehicle for planning complex programs, rapid evaluation of program status, and the timely identification of potential trouble areas."

Motorola's experience generally agrees with this view. The company has used Pert successfully in such programs as the AN/MRC-66 radio communications central for the Signal Corps, the automatic ground checkout system for Skybolt, the now canceled mission and traffic control system for the B-70. "The effectiveness of a Pert approach to a given program," cautions William S. Wheeler, vice president and general manager of Motorola's Military Electronics Division, "will be only as good as the quality of the analysis which defines the breakout of the program elements, the time and cost estimates of accomplishing the individual elements, and the time phase relationships of the elements to each other. However, everything else being equal, there is a better assurance of program success where one uses Pert than where one doesn't use it."

AFCS also recognizes Pert's limitations. It thinks it "may be able to put in cost estimates as well as time estimates in 'networking' a program," according to Sparrow. "We expect the first report on Pert applied to cost estimating this September from Harbridge House, Inc., Cambridge, Mass."

"If we put in cost estimates," Sparrow states, "we will use only one estimate instead of the 'optimistic, most likely, and pessimistic' estimates . . . Otherwise the cost data will overload the computer."

Simplicity boosts Able-Star

to reliability record

by Irwin Stambler, Associate Editor

SIMPLICITY was the prime consideration in the design of the Able-Star upper-stage system. From the start of the program, the engineers at Aerojet-General Corp., Azusa, Calif., were told to come up with a rugged system that would use only as many subsystems and components as were needed to achieve performance requirements. The success of this approach to reliability, Aerojet engineers told SPACE/AERONAUTICS, is proved by the Able-Star's launch performance: signaled to "go," the stage has started 22 out of 23 times. The system was also used in the recent triple-satellite launching that included the Transit IV-A, carrying the first orbital nuclear power supply.

The trap most system designers fall into is that they try to do all things for all people, states Marquis Bolton, of Space Electronics, the company responsible for design of the Able-Star's electronics package.* For the Able-Star, he told SPACE/AERONAUTICS, his company provided a system that will do what it is supposed to do and no more.

* Space Electronics has recently merged with Aerojet's Spacecraft Division in Space General Corp., an Aerojet subsidiary.

Able-Star Specs

Propellants	UDMH & IRFNA
Total impulse	approx. 2,300,000 lb-sec
Total burning time	approx. 300 sec
Gross weight	approx. 10,000 lb
Burnout weight	1,057 lb
Electronics-package weight	150 lb
Flight-loading basis	resistance to ultimate load, or 1.25 times limit load, without collapse or rupture
Design yield strength	1.1 times membrane stress resulting from limit loads

Thrust Chamber Configuration

	Nozzle Exit-Throat Area Ratio	
	20	40
Characteristic length (in.)	50.0	50.0
Nozzle throat area (sq in.)	21.64	21.64
Nozzle throat diameter (in.)	5.25	5.25
Nozzle exit area (sq in.)	432.8	865.6
Nozzle exit diameter (in.)	23.5	33.2
Chamber-throat area ratio	3.3	3.3
Chamber diameter (in.)	9.5	9.5

The Able-Star upper-stage system, designed by Aerojet around its AJ10-104 rocket engine, has performed yeoman service in boosting satellites of the Transit and Courier series into orbit. Claimed to be the first U.S. spacecraft stage that can be restarted, it is a direct descendant of the Able stage that sent Pioneer V into its orbit around the sun.

This first detailed design analysis of the Able-Star discusses how maximum reliability was insured in the overall structural arrangement and the handling of applied loads, in the engine configuration, in the electronics package, and in the control of start, restart, and attitude.

In designing the electronics package, Space Electronics used the best components it could get but as few of them as possible. Redundancy, states Bolton, has its pitfalls. He cites the example of a battery circuit intended to close a switch that lights a pilot lamp. Let's say you put in a second switch for safety. This sounds good—until you realize that, if a wire grounds, the whole system fails. Adding a second switch doubles the likelihood that a switch will close, but it also doubles the likelihood that a wire will ground.

A better solution would be to add a second, identical system—but that would impose a weight penalty. The best solution, says Bolton, and the one generally used on the Able-Star, is to see what's functionally wrong with the component to make you fear a failure and then fix it.

Figure 1 shows the straightforward basic design of the Able-Star. The propellant tank systems are all pressurized by helium. This eliminates the complex equipment needed for a turbopump installation and makes servicing easier. These advantages, Aerojet engineers point out, are gained without any loss in propulsion system efficiency. The chamber pressure at which the system works is 206 psia. Propulsion system development, Aerojet states, essentially has advanced to the point at which the chamber pressure of an upper stage can safely be dropped down enough so that the Able-Star's tank pressure is as low as the pressure needed to suppress cavitation in the more complex turbopump-fed systems.

One of Aerojet's main goals was to eliminate payload-upper-stage interface problems. The payload is

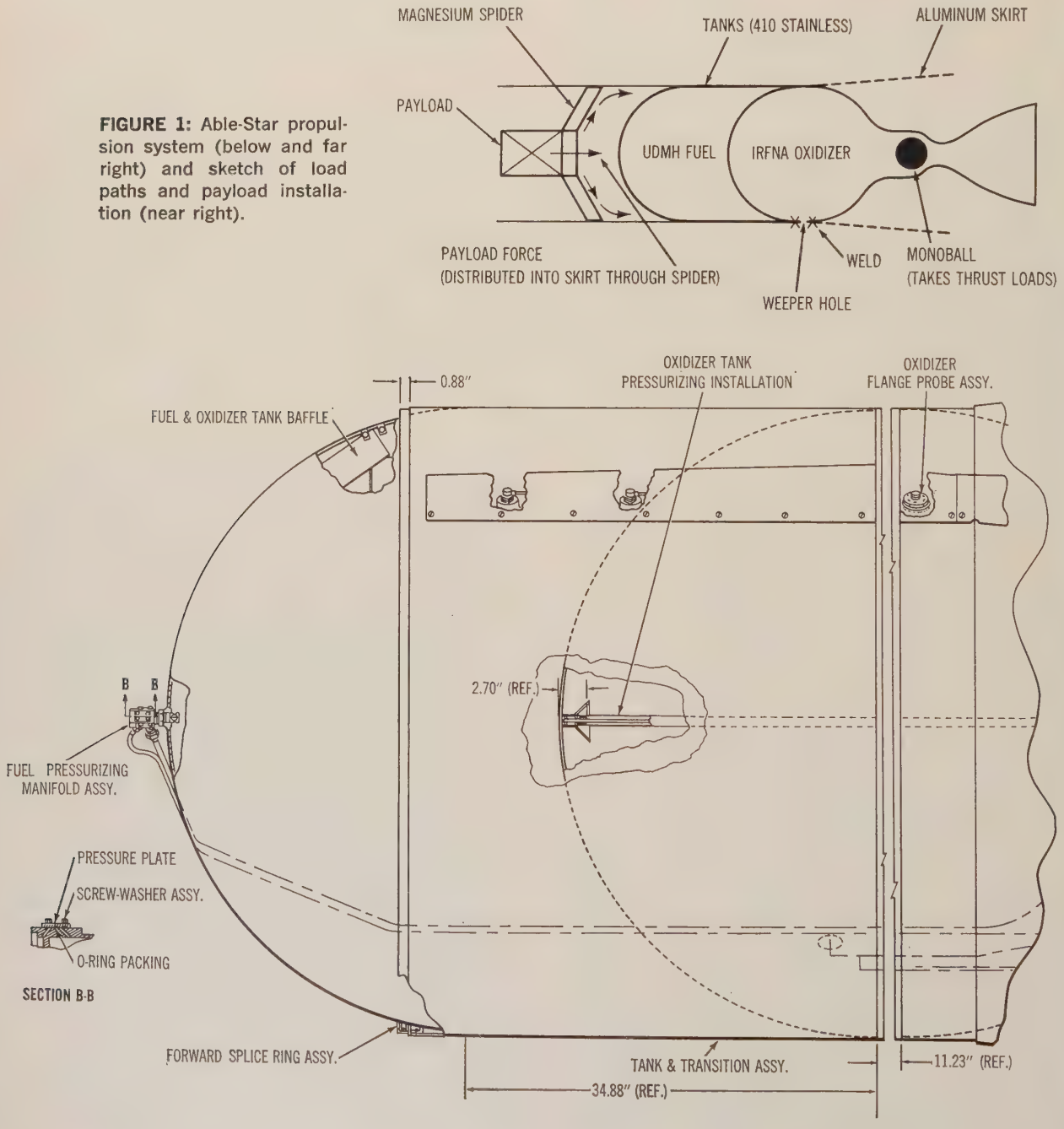
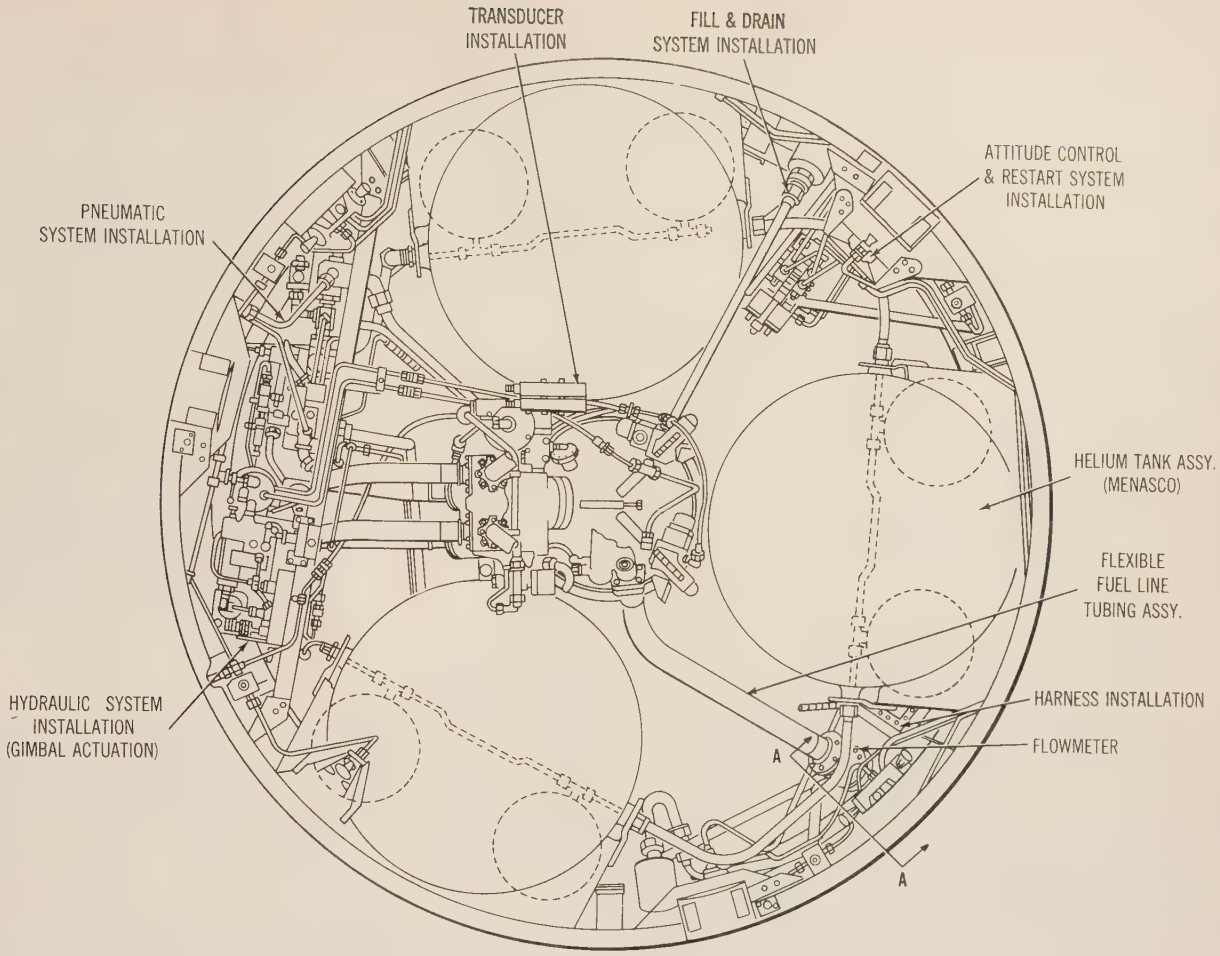


FIGURE 1: Able-Star propulsion system (below and far right) and sketch of load paths and payload installation (near right).


TRANSDUCER INSTALLATION
FILL & DRAIN SYSTEM INSTALLATION
ATTITUDE CONTROL & RESTART SYSTEM INSTALLATION
PNEUMATIC SYSTEM INSTALLATION
HELIUM TANK ASSY. (MENASCO)
FLEXIBLE FUEL LINE TUBING ASSY.
HARNESS INSTALLATION
FLOWMETER
HYDRAULIC SYSTEM INSTALLATION (GIMBAL ACTUATION)
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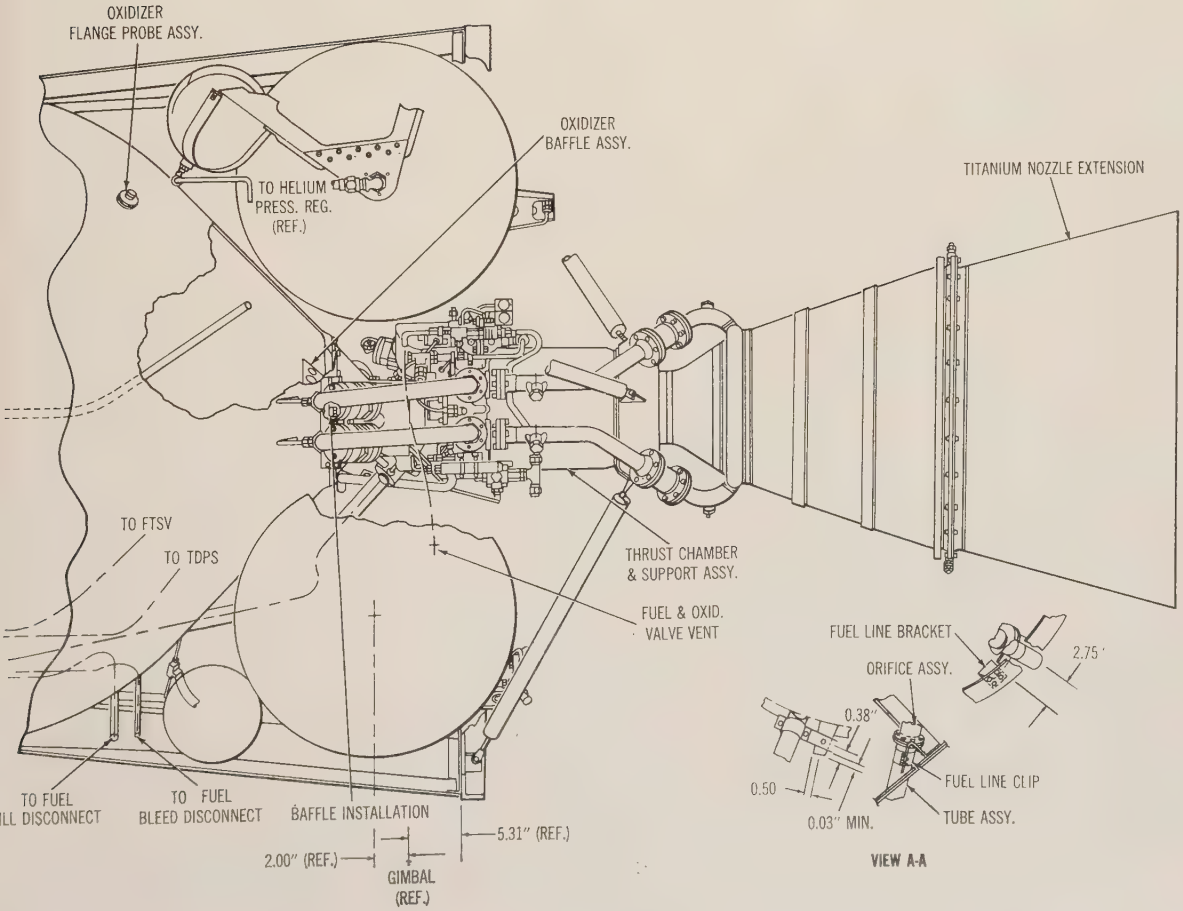
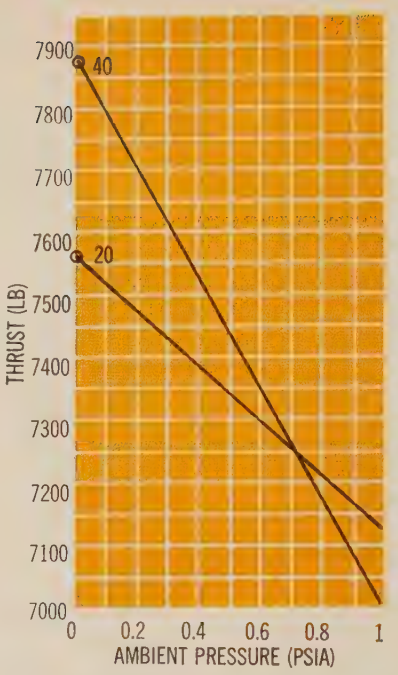

OXIDIZER FLANGE PROBE ASSY.
OXIDIZER BAFFLE ASSY.
TO HELIUM PRESS. REG. (REF.)
TITANIUM NOZZLE EXTENSION
TO FTSV
TO TDPS
THRUST CHAMBER & SUPPORT ASSY.
FUEL & OXID. VALVE VENT
TO FUEL ILL DISCONNECT
TO FUEL BLEED DISCONNECT
BAFFLE INSTALLATION
5.31" (REF.)
2.00" (REF.)
GIMBAL (REF.)
FUEL LINE BRACKET
ORIFICE ASSY.
2.75
0.38"
0.50
0.03" MIN.
FUEL LINE CLIP
TUBE ASSY.
VIEW A-A

Thrust Chamber Performance in Vacuum (Steady State)[1]

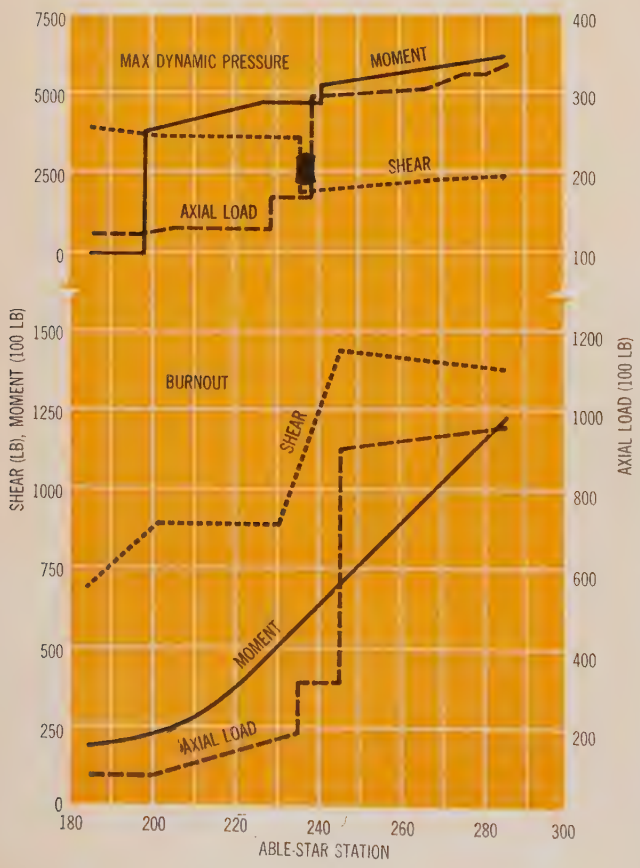
	Nozzle Exit-Throat Area Ratio 20	40
Thrust (lb)	7575 ± 3%[2]	7890 ± 3%[2]
Thrust chamber pressure (psia)	206 ± 6	206 ± 6
Minimum total impulse (lb-sec)		2,261,900[2]
Min. instantaneous specific impulse (sec)	263[3]	274[3]
Thrust coefficient	1.70	1.77
Min. characteristic exhaust velocity (fps)	4980[4]	4980[4]
Nozzle exit design pressure (psia)	1.3	0.43
Nozzle pressure ratio	158	476
Total propellant flow rate (pps)	28.36	28.36
Static oxidizer-fuel mixture ratio	2.80 ± 0.06[2]	2.80 ± 0.06[2]
Fuel flow rate (pps)	7.46	7.46
Oxidizer flow rate (pps)	20.90	20.90
Ratio of specific heats	1.20	1.20

(1) Estimated unless otherwise noted. (2) Rated. (3) Rated; estimated nominal values are 267 and 278 seconds. (4) Rated; estimated nominal value is 5060 fps.



ESTIMATED thrust vs ambient pressure for two nozzle exit-throat area ratios at 206 psia and a chamber pressure mixture ratio of 2.8. The design points apply with all conditions at their nominal value.

FIGURE 2: Maximum in-flight loads. (The cylindrical upper part of the Able-Star begins at the payload interface at station 188.18 and extends to station 245.68. From there, the interface skirt flares out until it reaches the booster at station 283.91.)



put on top of the Able-Star simply by attaching it to an eight-legged, built-up magnesium "spider." Besides designing a mechanical flange to adapt the payload to the Able-Star, they had nothing to worry about, Aerojet engineers state, since the two "packages" are functionally independent.

The present Able-Star design is based on payloads of up to 500 lb. Only minor modifications of the forward tank structure would be needed, Aerojet states, for much heavier payloads. The company proved the basic soundness of its design in the Aero-Star project when a 1000-lb solid rocket was placed on top of a basic Able-Star tank together with a 400-500 lb payload. Considerable bending moment loads resulted, but no changes in the tank design were necessary.

The tank structure (including the hemispherical tank ends) is made of 401 stainless steel, which proved to offer the best engineering solution for the pressurized and welded tank design. Aerojet reports that excellent welding properties have been obtained with this material. Pressurization places the tank walls in tension. Thus the forces of the payload in front of the tanks only serve to relieve the stresses on the vessel. If a certain bending moment is applied to the tank, it again serves to relieve the tensile load (*Fig. 2*).

The tanks are welded so as to prevent any mixing of oxidizer and fuel. Two welds are used, with a small weeper hole between them, and any propellant leaking past a weld seeps out without reaching the other tank.

The spider assembly transmits payload and inertial loads into the tank skirts. The lower skirt is made of mechanically connected aluminum alloy. Aluminum was chosen because this section must take a lot of bending load and also has a great many access holes. The monoball on which the tank assembly is mounted takes the thrust load directly into the tank walls. As a result, the tank head takes only pressurization loads.

Aerojet's design involves the use of relatively heavy tank skins. Theoretically, company jet engineers note, very thin skins could have been used. However, some loads still must be taken, and any extra load on the structure would pose a problem for thin skins.

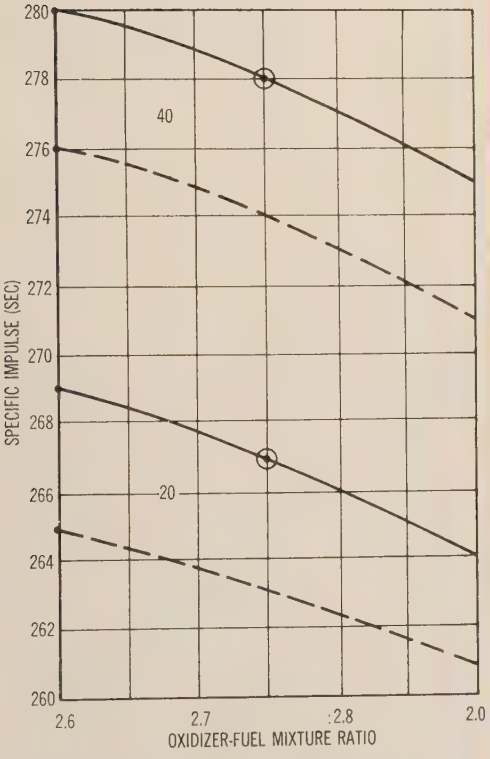
Clamshell shrouds of fiberglass laminate protect the Able-Star payload. The payload is separated by actuators and explosive bolts. The actuators apply equal bidirectional forces to push the clamshells far enough out of the way so they don't bang into the skirt as the Able-Star goes by the payload.

An aluminum monococque transition section connects the Able-Star to its booster. A fire-in-the-hole design is used for separation. The Able-Star is fired while on the booster as vent holes around the transition section are unported by removal of a ring band. Then explosive bolts are actuated to let the Able-Star move out on guide rails and separate smoothly.

Three 6Al4-V titanium pressure vessels for the helium system are mounted on the aluminum skirt. Each is 23.6 in. in diameter. The spheres were designed to withstand 5500 psi, but testing showed that they can take over 6000 psi. The use of titanium saved some 60 lb, Aerojet states.

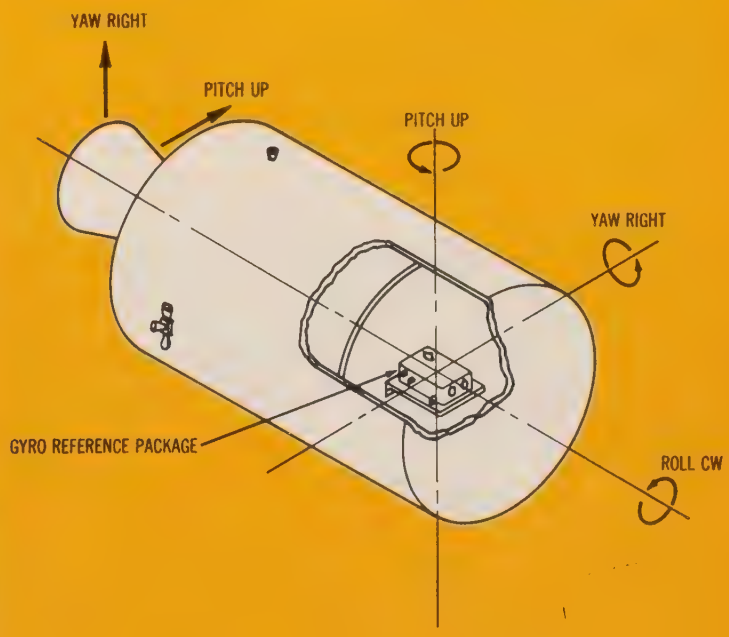
An even more impressive gain was achieved by the use of a titanium skirt for the uncooled engine nozzle. The skirt increased the thrust-chamber expansion ratio from 20 to 40, upping the specific impulse by 10 points and the thrust by 300 lb, at a cost of only about 10 lb of extra weight.

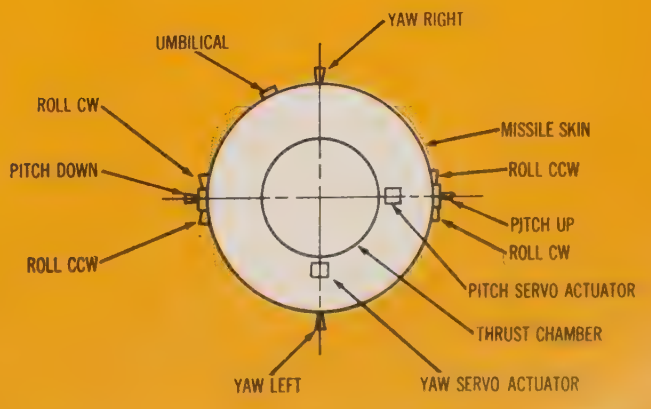
In addition to the AJ10-104 propulsion system, the Able-Star has a force control system for roll, pitch and yaw, an electronics package, and a guidance system (designed by Bell Telephone Labs). The force control system is slaved to the autopilot system. During powered flight, the thrust chamber can be gimbaled to



ESTIMATED specific impulse vs mixture ratio for two nozzle area ratios and characteristic exhaust velocities of 5060 fps (solid) and 4980 fps (dashed) at 206 psia chamber pressure. The design points apply with all conditions at their nominal values.

FORCE CONTROL system arrangement. The cross-sectional view is looking aft. (It would correspond to the cross-section in Figure 1 if reversed to look forward and turned 135 deg counterclockwise.)





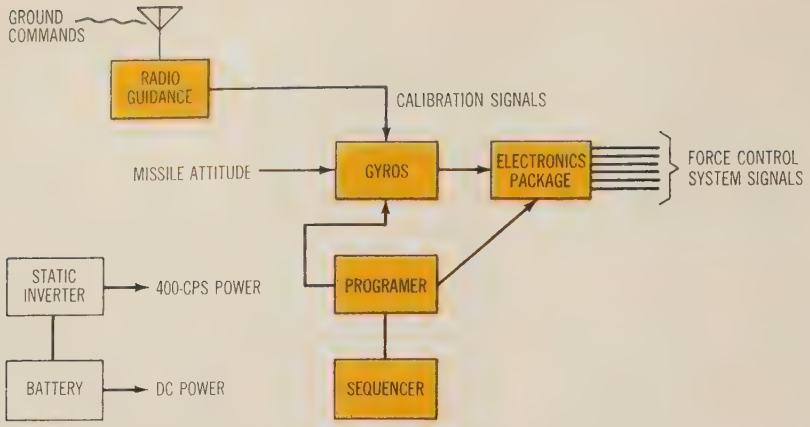


FIGURE 3: Main components of guidance and control system electronics.

control pitch and yaw. As there is only one chamber, it can't provide roll control—two jets using nitrogen gas are used for that.

During coast, when the chamber can't be used for pitch and yaw, four more nitrogen jets provide pitch and yaw control.

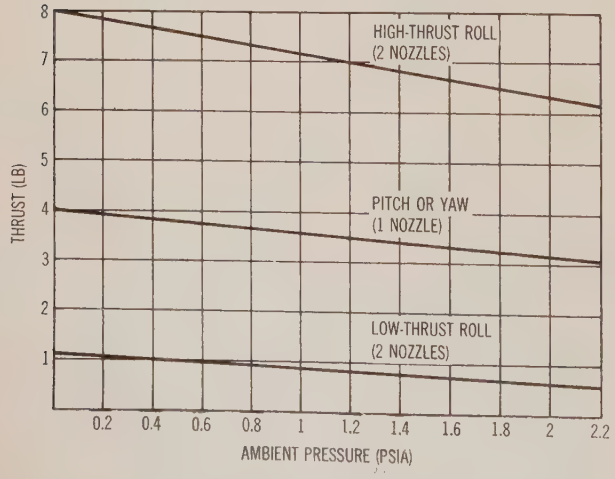
The Able-Star, Aerojet claims, was the first restarting spacecraft stage to be designed in the U.S. An important consideration for restart is that, after a long coast, weightlessness tends to make the propellants drift around inside their tanks. For restart, you want to get the propellants back into the tank bottom. In the Able-Star, this is done by applying a subtle thrust influence. The force control system also includes provision for using two jets to apply nine pounds of thrust for 23 seconds so any pressurizing helium will bubble out of the settled propellants.

Able-Star is an integrated system

One of the reasons for the Able-Star's high reliability, Bolton states, is that it is a truly integrated system. Some other designs, he points out, have run into problems because they started as propulsion systems, with the electronics "slapped on" later. The Able-Star electronic system, says Bolton, was designed right along with the overall stage.

The electronics package uses an inertial reference system with three precise gyros as an attitude sensor for roll, pitch and yaw. In this design, which is not as sophisticated as an all-inertial system, the gyros are body-fixed. Their output is fed into an electronics assembly in which all the logic elements of missile dynamics—shaping networks, amplifiers, demodulators, etc.—are contained. The output of this package supplies the information for the force control system—signals to the pitch and yaw gimbals on the engine for the powered phase and to the solenoid valves operating the gas jets for powered roll and for coast.

ESTIMATED thrust from force-control nozzles.



Programer provides stage direction

A stage programer provides overall stage direction (*Fig. 3*). Fed from a sequencer, it signals the gyro system to turn the missile (mainly in pitch). In addition, it signals the engine when to start and restart, triggers the discarding of the nose fairings, and sends various safety and backup signals.

The radio guidance system can override the programer at certain times. Essentially, the programer controls the electronics package and tells it when to consider the missile in powered and when in unpowered flight. However, one problem of an upper stage is that it has to make up for any deficiency of the booster. If the booster shuts off prematurely, the programer doesn't know it. The radio link then comes in to realign the system. In addition, it shuts off the engine at the end of the first burning period.

After a long coast, the Able-Star has gone a quarter of the way around the world and is out of the line of sight of radio guidance. The programer now restarts the engine, but the radio link can no longer tell the engine when to shut off. An integrating accelerometer therefore is used in this phase to measure the acceleration and integrate it. The output is an axial velocity. When it reaches a preset velocity value, a signal is sent to the programmer to shut down the engine.

The battery system for the electronic equipment provides 20-32 V for all units, including the static inverter. The inverter supplies 400 cps for the gyro package.

Space Electronics also designed the standard FM-FM telemetry system, which is a complete package that includes its own battery and transmitter. The system's data converter takes data from transducers and other equipment to the data conditioner. The latter supplies the output to the transmitter, which excites the antenna. Seventy-four channels are available. Considerable multiplexing is used to get some 200 pieces of data from a small package.

Lift fans: cheap, flexible and light VTOL propulsion

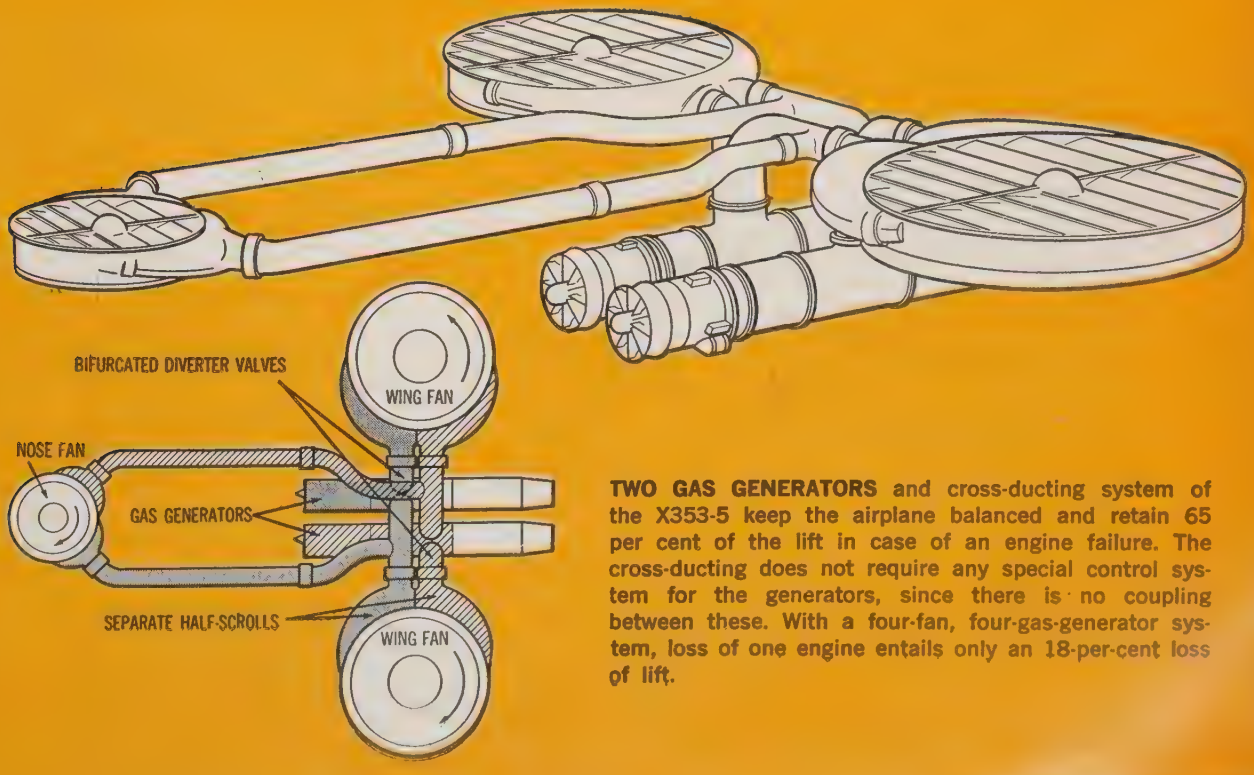
by B. H. Rowe, Applications Engineer,
Flight Propulsion Laboratory Dept., General Electric Co.*

The wide variety of STOL and VTOL planes designed over the last few years includes rotary-wing craft and both propeller and jet-driven types. When the field is narrowed down to tactical military VTOLs, the choice is limited to two basic systems, both based on jets. One uses separate engines for vertical lift and horizontal propulsion, the other uses the same engines for both purposes. If lift engines are used, they can be rotated to add to the level thrust, or their exhaust can be deflected to produce a downward thrust, or they can drive a lift fan.

The lift fan system offers several advantages in weight, control, fuel consumption, and power conversion. GE has developed its X353-5 lift fan to the point where it is ready for installation in an experimental aircraft. It is designed for thin wings and secures most of the other possible advantages of this type of system.

THE X353-5 LIFT-FAN VTOL system consists of a jet engine, a diverter valve, and the lift-fan assembly itself (*Fig. 1*). The valve controls the passage of the hot gas exhaust from the jet engine through a duct and to the fan. For vertical flight, the valve directs the exhaust to the tip turbine around the outer edge of the fan. After takeoff, movable louvers under the fan are turned to produce forward thrust. Once the plane has gained enough forward speed to be supported

* Flight Propulsion Laboratory Dept., General Electric Co., Cincinnati 15, Ohio.



TWO GAS GENERATORS and cross-ducting system of the X353-5 keep the airplane balanced and retain 65 per cent of the lift in case of an engine failure. The cross-ducting does not require any special control system for the generators, since there is no coupling between these. With a four-fan, four-gas-generator system, loss of one engine entails only an 18-per-cent loss of lift.

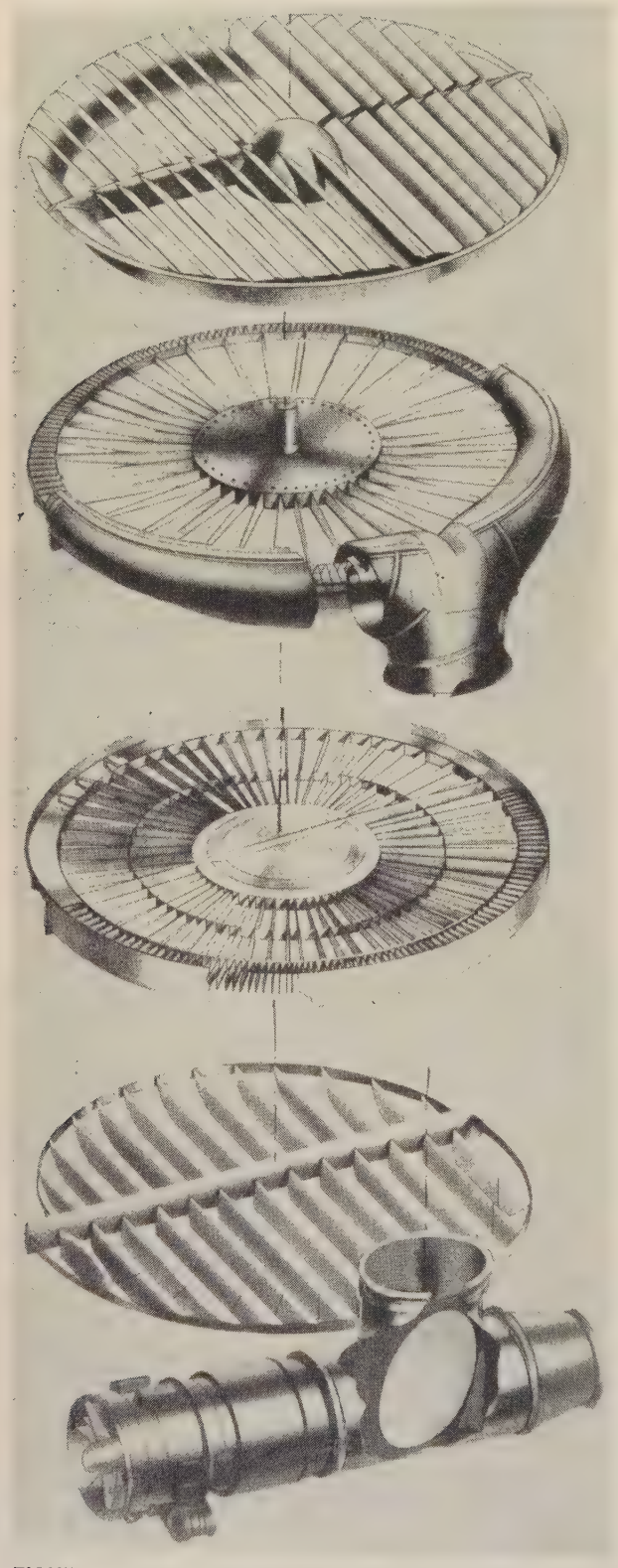


FIGURE 1: X353-5 consists of (top to bottom) front frame, rotor and scroll, rear frame, exhaust louvers, and gas generator, diverter valve, and nozzle. The inlet and exhaust louver systems and the diverter fan are positioned for maximum vertical lift.

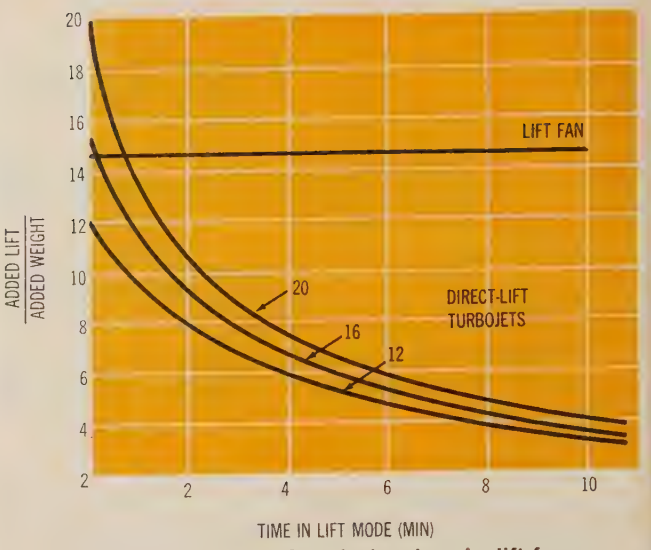


FIGURE 2: Comparison of typical subsonic lift-fan system and direct-lift turbojets at various ratios of thrust to dry weight and an SFC of 1.3. As both types of engines have a forward propulsion that can be diverted for lift, the remainder of the total lift that must be supplied at "added weight" (including fuel) is "added lift".

by its wings, the valve shuts off the fan, directing all the exhaust through the engine nozzle for normal jet thrust.

Besides lower exhaust velocities, temperatures, and noise levels, the lift-fan system has several advantages over a VTOL system with separate jets for the VTOL and forward-flight phases:

- It does not use extra fuel for takeoff.
- It can be coupled to different jets without modification of its hardware or its control design.
- It has a better thrust-weight ratio, for VTOL operating times of over one minute (*Fig. 2*).

The design of a lift-fan system and its installation on an aircraft wing involve several problems of thickness and weight. The X353-5 fan fits into a 144-in.-chord wing with an NACA 65210 airfoil. The center of the fan is at 40 per cent chord; spars can be at 13 and 67 per cent. The fan's thickness tapers from a maximum of 14.4 in., to 10.3 in.

Front frame acts as fan-rotor inlet

The major parts of the lift-fan are the front frame, the rotor, the turbine hot-gas scroll, the rear frame, and the inlet and exhaust louvers. The front frame is the primary mounting and supporting structure for the other components and also acts as an efficient inlet for the fan rotor. It is attached to the wing at three points. The fore and aft mounts are at the points where the deep primary strut joins the bell-mouth inlet and take all the major loads of thrust, lift, gyro effects, and distortion. The third mount, at the end of the secondary half-strut, takes only the loads due to gyro moments from pitch and cross-flow. The inner ends of the struts are attached to the central bearing housing supporting the rotor.

As the primary strut is placed parallel to the flight stream, it can, if necessary, protrude above the wing, with negligible drag. This arrangement is lighter than a Y-strut system. The secondary strut runs below the surface of the wing. The struts are sized to limit the

deflection of the rotor tip to ±0.7 in. under the worst combined loading.

The 72.5-in.-diameter rotor can be considered a single-stage, axial-flow compressor driven by a peripheral impulse turbine. It is supported on a stub shaft by two bearings carried in the front frame bearing housing. There are 36 fan blades, whose aspect ratio of over 6 and constant thickness of six per cent makes for a lightweight design. The blades are attached to a hollow disk by a three-tang dovetail system (*Fig. 3*).

Centrifugal force imposes strain

The rotor turbine ring is made up of 18 bucket and carrier assemblies, each of which has 18 turbine buckets (*Fig. 4*). Weight and strength are particularly important in this design because of the severe strain imposed on the fan blades and the supporting structure by the multiplication of peripheral weight by centrifugal force. Gyro moments are also greatly magnified. The bucket and carrier assemblies are made of Inconel sheet and machined bar stock, which are brazed together. Each assembly is pinned to two rotor blades, and the entire ring of 18 assemblies is tied together by bolting them to a René 41 torque band that also forms the fan blade tip shroud.

The main functions of the rear frame are to straighten the fan exhaust flow and support the exit louver system. To give the flow-straightening stators as high an aspect ratio as possible without causing flutter, a circular support ring divides them in two (*Fig. 5*). The effective aspect ratio is 6.25 for each half, rather than 12.5 for the entire blade assembly.

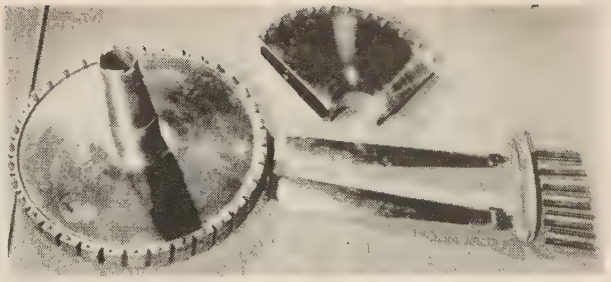


FIGURE 3: Rotor disk, blades, turbine buckets, and bucket carrier before assembly and brazing.

FIGURE 4: Turbine bucket and carrier assembly. Rotor blade tips enter between each pair of cross beams and are pinned to these.

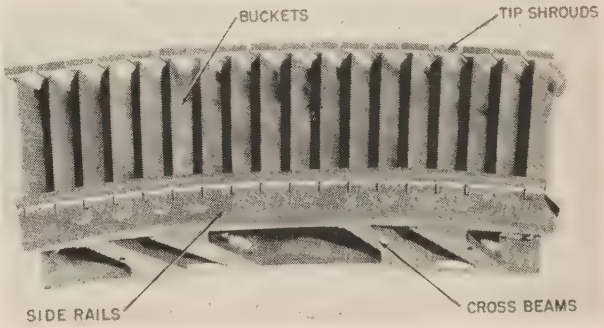
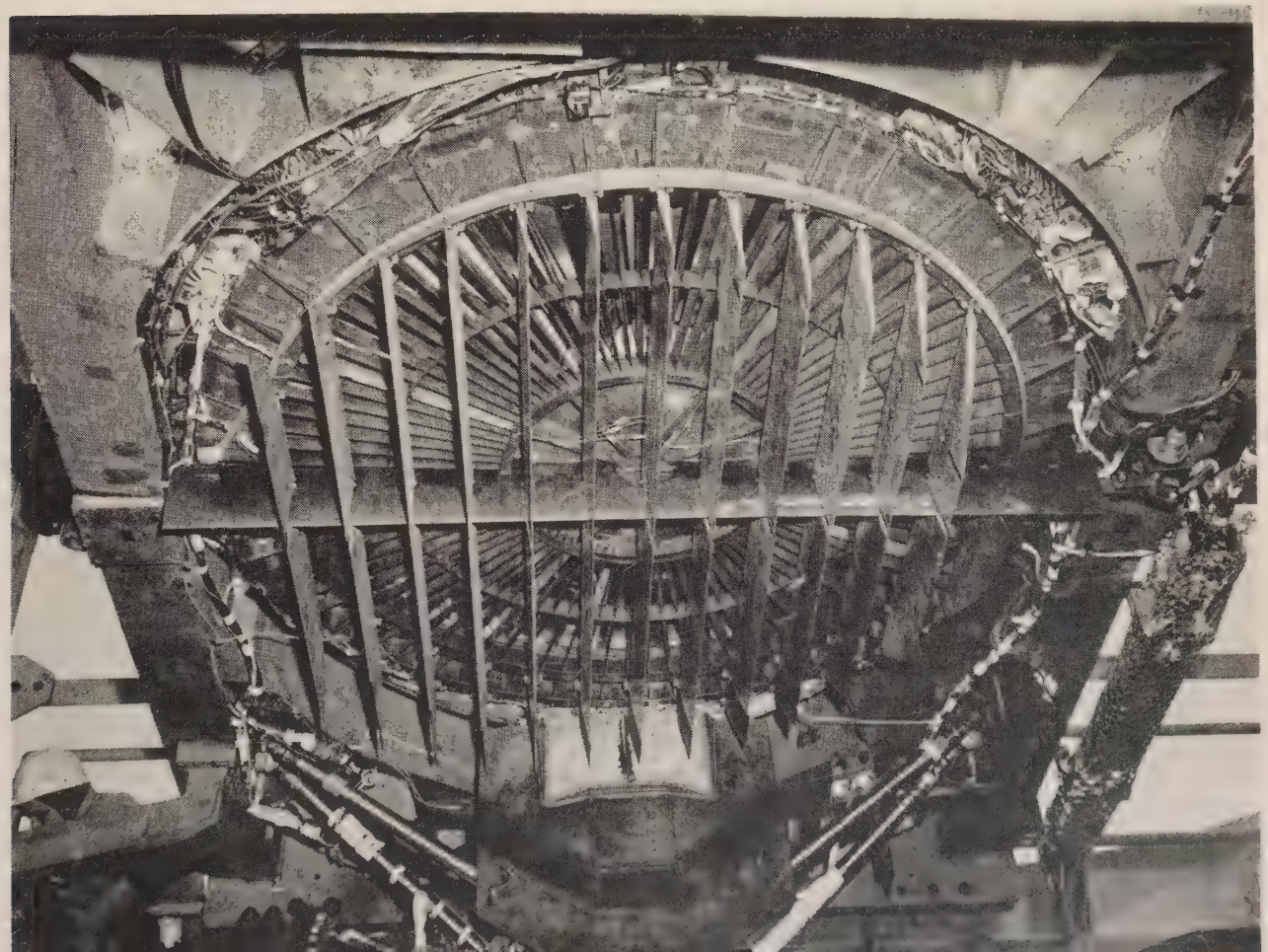


FIGURE 5: Underside of rear frame and exhaust louver system with the central support ring for the stator blades and the support strut.



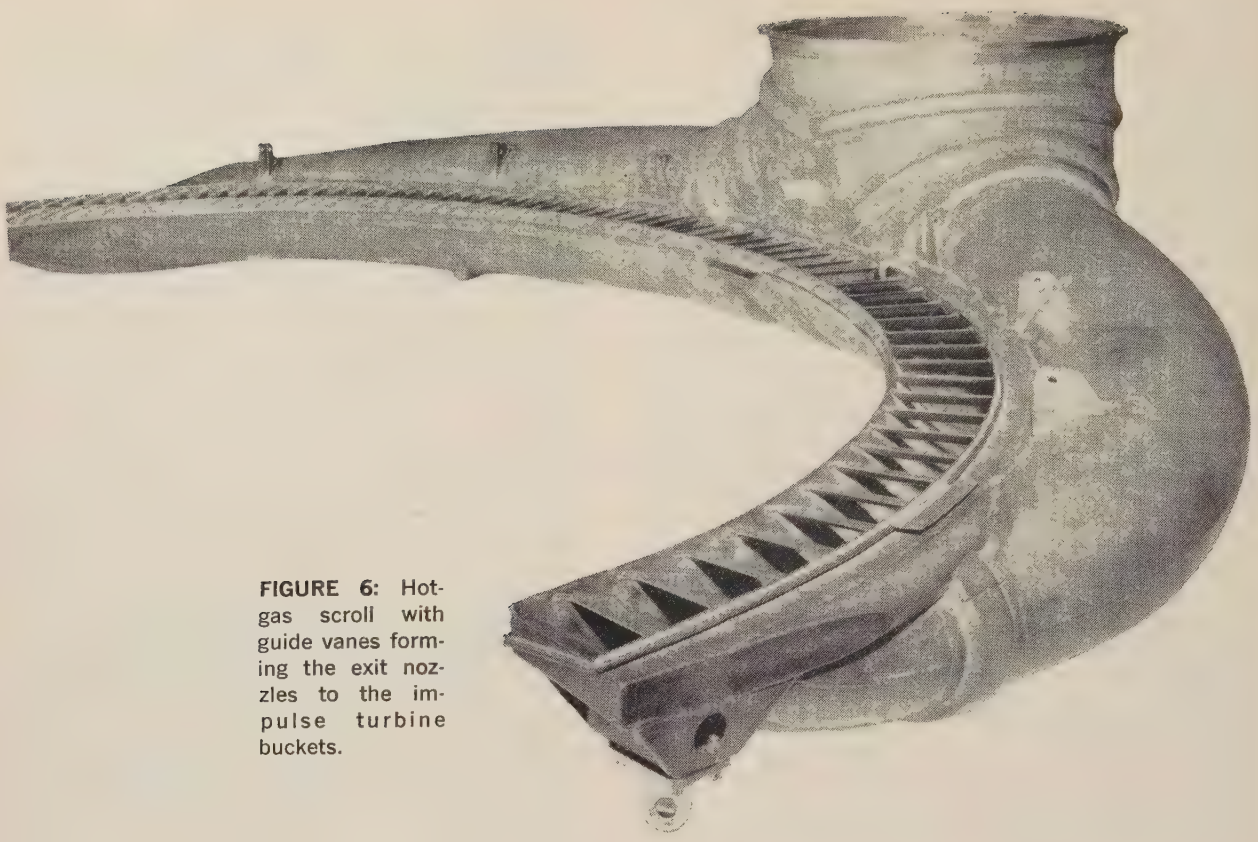
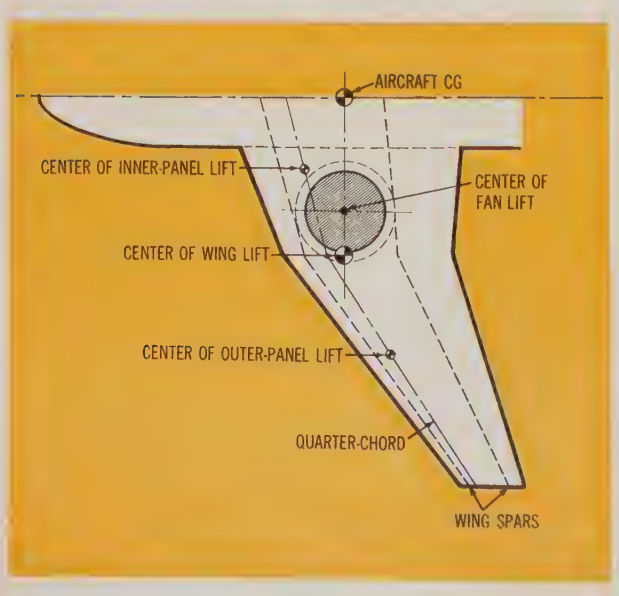


FIGURE 6: Hot-gas scroll with guide vanes forming the exit nozzles to the impulse turbine buckets.

The rear frame is axially stiffened by a deep support strut aligned with the primary strut of the front frame and tied into it through support boxes. The inner edges of the support strut act as stator blades and reduce aerodynamic losses. The strut also acts as the center support and housing for the exit louver actuation system. The entire frame is built up from Inconel sheet, with over 700 joints brazed in one furnace run.

FIGURE 7: Relationship of the centers of lift of inner panel, lift fan, and outer panel and the aircraft CG. The outer wing panel is swept back to make them coincide.



The turbine hot-gas scroll ducts the J855 exhaust through the nozzles to power the turbine (*Fig. 6*). It is welded from L605 sheet. (This cobalt-base alloy is 10 per cent heavier than Inconel, but much easier to work and weld.) The flow Mach number and area distribution for the scroll gas were chosen so that the fan could be fitted into the wing contour. The scroll entrance is in the thickest part of the wing, and the flow is equally divided between the two arms. The scroll is fixed rigidly at the center, while the arms are allowed to expand along fixed pins in the front frame. This mounting transfers loads directly to the fan mounting points and also gives the scroll a positive location in relation to the fan's axis of rotation.

The inlet and exhaust louvers close off the wing surfaces when the fan is not operating. The inlet louvers also help direct air into the fan with a minimum of distortion loss, while the exhaust louvers vector the fan exhaust stream to produce either thrust and lift or pure lift in transition flight.

Hover phase presented problems

The hovering phase presented several problems for the control design of the X353-5. The centers of lift of the fans and the wing had to be aligned approximately with the aircraft CG to simplify pitch control. With the center line of the fan at 40 per cent chord, the outer wing panels would have to be sharply swept back to meet this requirement (*Fig. 7*). This wing planform would probably be satisfactory aerodynamically, but it would have to be stiffened to resist the extra torque moment from the swept outer panels.

Since some form of pitch control is also required, a better solution is to use a nose fan to balance out the centerline-CG difference as well as to control pitch in hovering by increasing or decreasing the nose fan lift (*Fig. 8*). A nose fan is preferable to a tail fan because it adds lift, whereas a tail fan would subtract lift.

Studies show that, for an aircraft of 13,000 lb gross weight, the required control moments are 15,250 lb-ft for pitch, 22,000 lb-ft for yaw, and 6700 lb-ft for roll. With the pitch control provided by the nose fan, roll control can be achieved with the wing lift-fans in either of two ways:

- The wing fans can be oversized, and their lift can be spoiled by the inlet or exhaust louvers or some other spoiling system.
- A complete power transfer system can be used to vary the power split between the two fans without a change in the engine throttle setting. This system requires either fans with variable inlet guide vanes or lightweight rotors with variable-area scrolls.

Nozzles control pitch and roll

Pitch and roll can also be controlled by variable-area nozzles in the wing tips and in either the nose or the tail. For yaw control, differential vectoring of the exit louvers can be used with any of these systems.

The *Table* compares these control systems. The most important advantage probably lies with the power transfer system, which requires the smallest fan diameter and therefore the smallest wing (whose lower drag increases the range). The fans with the higher pressure ratio are better for transition from hover to cruise because of their inlet characteristics at low ratios of flight to fan airflow velocity. The first research plane powered by the X353-5 will probably use the spoiler control system, which can be produced with only slight modification of current hardware.

Design work on the X353-5 began in 1958, and the first fan was put on test in November 1959. Since then, powered by a GE J85-5, it has been tested for over 110 hours both statically and in wind tunnels. The system has shown a vertical lift of over 7000 lb and an SFC of 0.365 lb/lb/hr. Twenty-three hours of the testing was at over 75 per cent fan speed, the equivalent of about 300 four-minute VTOL missions.

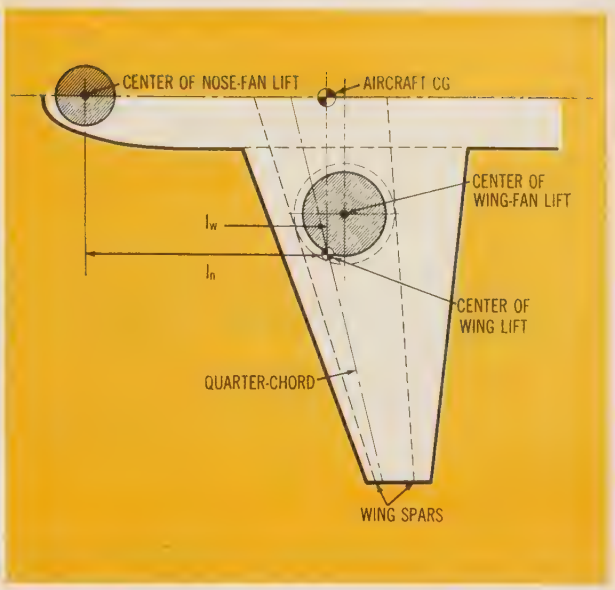


FIGURE 8: Nose lift fan counteracts the displacement of the center of wing-fan lift from the aircraft CG and the center of wing lift. The requirement for balanced hovering is given by: $W_n - 2W_w l_w / l_n$, where W_n is the nose-fan lift; W_w, the wing-fan lift; and l_w and l_n are the distances from the center of wing- and nose-fan lift, respectively, to the aircraft CG. The total lift equals $W_n + 2W_w$, or 1.1 times the gross weight.

The fan has been put through cross-flow in NASA-Ames' full-scale wind tunnel, which showed that the steady-state and vibratory stresses are within allowable limits under all conditions. The rotor passed through its critical frequencies in both the static and wind-tunnel testing without excessive build-up of vibratory stresses, so that the aerodynamic test points could be taken throughout the full operating range.

Preliminary evaluation of the wind tunnel tests shows that the system is capable of transition from vertical to horizontal flight. The tests also showed good longitudinal stability for the major variables (flight speed, angle of attack, thrust-vectoring angle, etc.).

Lift-Fan Control Systems

	Exhaust Bleed Jet Control	Oversized Fans with Lift Spoilers	Variable-Lift Fans with Power Transfer
Max. main fan diameter (in.)	79.1	85.5	74.4
Main fan pressure ratio	1.07	1.07	1.102
Max. control fan diameter (in.)		43.6	37.7
Max. pitch control gas flow (pps)	16.4	9.7	12.36
Relative weight of two 2 lift-fan systems	1.024	1.065	1
Relative wing area (at constant span & tip chord)	1.069	1.126	1
Relative aspect ratio	0.935	0.885	1
Relative range (at 13,500 lb gross weight, 2000 lb payload, 10% fuel reserve)	0.960	0.9	1

Luminous bar indicators

cut down readout errors

by **Albert L. deGraffenried,** Staff Scientist, Avien, Inc.*

Many of the display devices used with aerospace instrumentation systems are difficult to read and interpret. Human-factors studies show that luminous bar graphs offer a display that strongly tends to minimize readout errors.

Avien has been studying an electroluminescent vertical indicator that uses light columns of variable weight. Basically this "Elvis" system is a voltmeter or ammeter that senses voltage or current by applying an AC electric field to a layer of electroluminescent material sandwiched between a fixed, transparent electrode and a movable, opaque one. The movable electrode is a rising or falling column of mercury. Light appears at the exact level of the mercury.

Elvis provides a great deal of operating information in a logical sequence and so reduces not only readout errors but also system trouble-shooting time. In a special application, a color display varies continuously from a deep blue at minimum temperature to a high red at maximum. Elvis can also be used as an analog function generator and as an analog-digital converter.

WITH ANY MODERN aerospace instrumentation system, the probability that all indicators will be read and recorded properly decreases rapidly with the number of variables that must be scanned in succession—and this number is increasing steadily as equipment becomes more complex. The size, shape, and arrangement of visual indicators plays an important role in countering the trend toward readout errors.

The luminous bar graph has been proved to reduce scanning and reading errors to nearly optimum values. In this arrangement, a column of light rises vertically to indicate an increase in magnitude. By changing the color of the light, additional functions can be indicated without making the indicator any larger.

Figure 1 shows the operating principle of the basic luminous-bar module, or "*el*ectroluminescent *v*ertical *i*ndicating *s*ystem" (Elvis), we have been studying. The glass base plate, through which the light is observed, supports a vacuum-deposited, transparent metal layer acting as a front electrode. Behind this layer is the electroluminescent mosaic—a low-temperature glass or ceramic frit in which electroluminous phosphors are dispersed in a solid suspension.

Ceramic layer protects mosaic

A thin layer of low-temperature ceramic protects the mosaic from the moving column of mercury directly behind it. This column acts as a movable rear electrode. The back plate is merely an enclosing support and can be glass, Plexiglas, or metal.

When an AC excitation voltage is applied between the transparent conducting layer and the mercury, the phosphor particles in the electric field between them are excited to produce a characteristic glow. The color of this glow depends on the type of phosphor that is used. Only the particles opposite the mercury column give off light—the particles above the column remain dark. As the mercury column rises and falls, therefore, the observer sees a moving luminous column.

Refined for practical use, Elvis is essentially a voltmeter or milliameter—it moves a column of mercury to produce a column of light equivalent to a voltage

* Avien, Inc., 58-15 Northern Blvd., Woodside 77, N.Y.

or current input (*Fig. 2*). The basic sensing circuit is a bridge made up of R_a, R_b, R_c, and R_h, which is located inside the display unit and is inversely proportional to the height of the mercury column. As the mercury rises, it shorts out a portion of R_h. When the mercury is at "zero" level, R_b is adjusted to equal R_h and the bridge is in balance for a zero signal input.

If an input signal (e_{in}) is applied, its full value appears across the amplifier input, because at zero level the bridge output voltage (e_b) is likewise zero. The amplifier output is rectified and applied to a solenoid that produces a magnetic field of opposite polarity to that of a magnet fastened to the diaphragm of the display unit. The opposing fields produce a force against the diaphragm which raises the column of mercury.

The mercury rises to a height that decreases R_h sufficiently to produce a bridge output voltage (e_b) equal and opposite to e_{in}. At that point, the system is again in balance and the length of the column is a

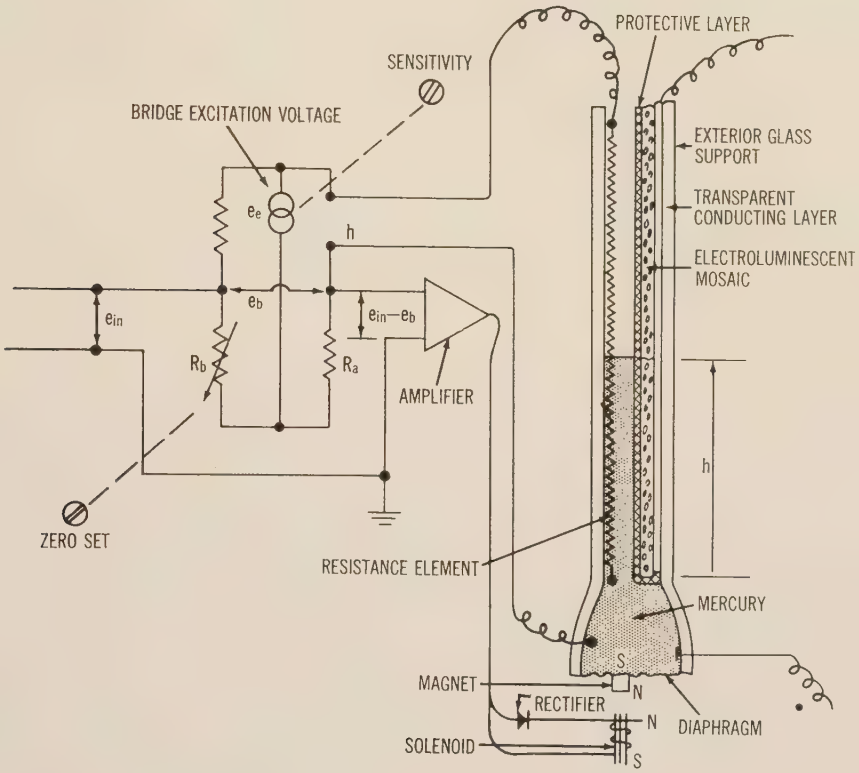


FIGURE 1: Elvis actuating system. Input drives the mercury column upward.

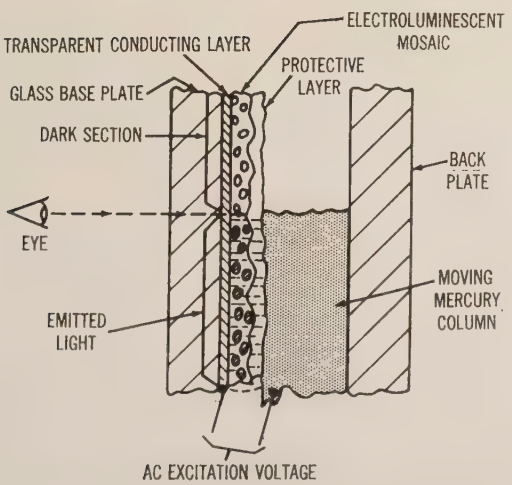


FIGURE 2: Basic design of the Elvis display.

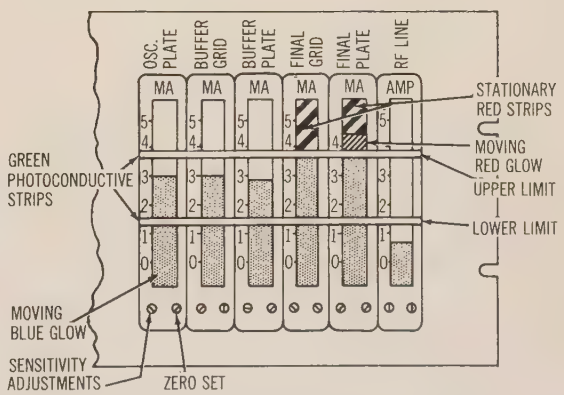


FIGURE 3: Elvis display for a VHF transmitter. Green limit strips trigger relay alarms. Operation above upper limit produces striped or solid red glow.

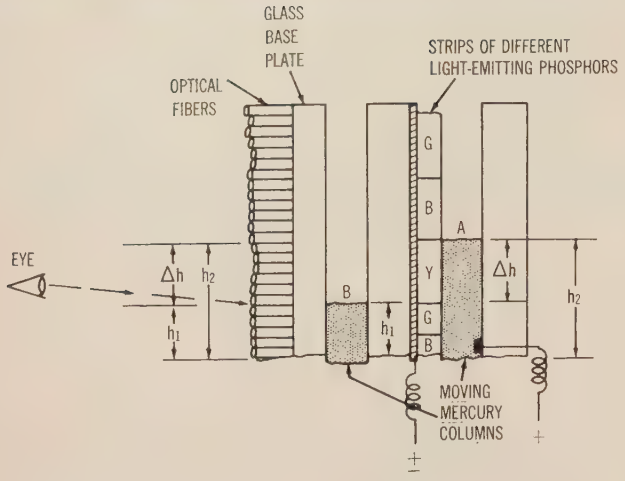


FIGURE 4: In an Elvis color modulator, striped patterns of color on the mosaic are varied in intensity by tandem columns of mercury and blended into tints by randomly oriented optical fibers.

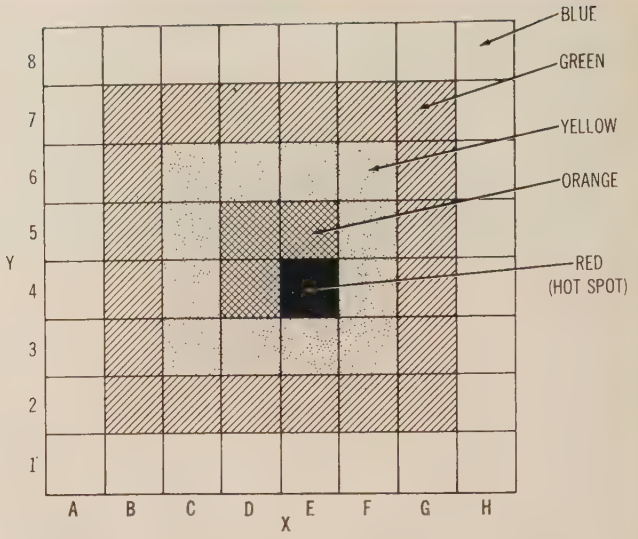


FIGURE 5: Color modulator matrix for the display of temperatures in various sections of a nuclear reactor. Color is a function of temperature and location, changing from cold blue to hot red with temperature rise.

direct function of the input signal magnitude. The sensitivity of the system—the length of the light column for a given input—is adjusted by variation of bridge excitation voltage level.

A battery of Elvis displays can be arranged side-by-side to provide compact visual monitoring of multiple stations or functions. *Figure 3* shows displays for the grid, plate, and RF line currents of a VHF transmitter. Configuration, color, and contrast provide a large amount of significant information in a small space.

Horizontal strips define limits

Two photoconductive green limit-strips run horizontally across the entire display. The sensitivity of each measurement is adjusted so that the normal operating condition for each function falls between the lower and upper limits defined by these horizontal strips. Because the limit strips are photoconductive, the passing of any luminous glow below the lower or upper limit can trigger a relay and sound an alarm.

In addition, when any value reaches a dangerous upper limit, the mercury column contacts several deposited metallic strips behind a red phosphor, producing a diagonal red grid. If the measured value exceeds the upper limit, the mercury supplies the contacts between the strips and produces a moving red bar. The height of the solid bar of light indicates how far above the danger point the quantity has risen.

With this type of display, malfunction sets off an alarm, and when the operator scans the display it's very unlikely he will make an error in observation. He's also unlikely to make a wrong trouble analysis, because scanning the display from left to right is analogous to scanning the transmitter circuit stage by stage from the beginning, or the oscillator, to the RF output.

Different colors can be used in the Elvis system. In an Elvis color modulator, the mosaic includes horizontal phosphor strips that emit different colors of light. The unit shown in *Figure 4* has a blue strip at the bottom and two moving columns of mercury. With column A at height h_2, the blue, green, and yellow phosphors emit light. With column B always at a level Δh below A, the observer sees yellow plus a tiny bit of green as two horizontal strips of light.

To provide an indicating element in which the color changes evenly over the entire surface it occupies, a bundle of randomly arranged optical fibers scrambles the light from the strips. The result is a blend of yellow and green, or yellow with a green tint. The optical fibers are placed between the observer and the glass base-plate.

Figure 5 shows an 8×8 matrix of color modulator areas. The tandem mercury columns are driven by a voltage that represents temperature. The colors are arranged so that, as the temperature increases from minimum to maximum, the color blends gradually from a cold blue to a hot red. This arrangement could, for instance, be applied to the various areas of a reactor.

One photo-cell monitors display

Isotherm lines are represented by isochrome lines. The operator can immediately recognize the temperature topography of the reactor. Element 4E in this case is at a dangerous temperature peak. The entire display can be monitored by a single photocell and a narrow-pass optical filter with the proper skirt contour. This monitor can be arranged to notify the operator of the following situations: one red element, two orange elements, and five yellow elements.

The Elvis module can be combined with a function mask and a photoconductive element to provide an

analog-function generator (*Fig. 6*). The mask representing the function is placed between the Elvis mosaic and the photoconductor.

The total light flux ($\Sigma\phi$) reaching the photoconductor for a given column height (h) and a given function mask of curvature $f(h)$ is:

$$\sum \phi \propto \int_{o}^{h} Bf(h)dh,$$

where B is the light-flux density. If we make the lower limit a variable (h_1), the total flux falling on the photoconductor becomes:

$$\sum \phi \propto \int_{h_1}^{h_2} Bf(h)dh.$$

All parameters can be varied with time, and the masks can be changed periodically, so that we can compute:

$$\sum \phi \propto \sum_{1}^{n} B_n(t) \int_{h_1(t)}^{h_2(t)} f_n(h)dh.$$

Elvis can also be used as an analog-digital converter (*Fig. 7*). In this case, the mask has two rows of staggered slits. There are now two photoconductive elements, one opposite each row of slits. The upper ends of the photoconductors go to different DC supplies, while the bottom ends terminate in a common load resistor. When the light column is at the bottom, the voltage across the load resistor is zero.

Light produces positive voltage

As the column of light rises, it first passes through the lower left-hand slit, reducing the resistance of the left-hand photoconductor and producing a positive voltage across the load resistor. The rising light then passes through the lower right-hand slit and falls on the right-hand photoconductor, making both photoconductors equally conductive and reducing the voltage across the resistor to zero.

With a further increase in column height, light next falls on the right-hand photoconductor, reducing its resistance below that of the left-hand one and producing an output of negative voltage. In *Figure 7*, a tri-binary output is produced—the voltage goes from positive to zero to negative to zero, and three logic levels are provided. By proper design and close spacing of the slits, the Elvis analog-digital converter can be made to produce a true (plus or minus) binary output.

FIGURE 6: As the luminous column of the Elvis analog function generator rises, the total light reaching the photo-conductor through the mask is a function of illumination intensity, height of the light above the base reference, and curvature of the aperture mask.

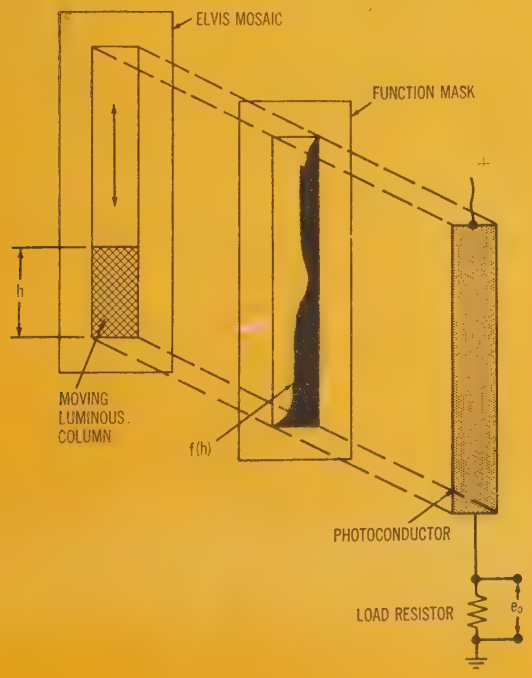
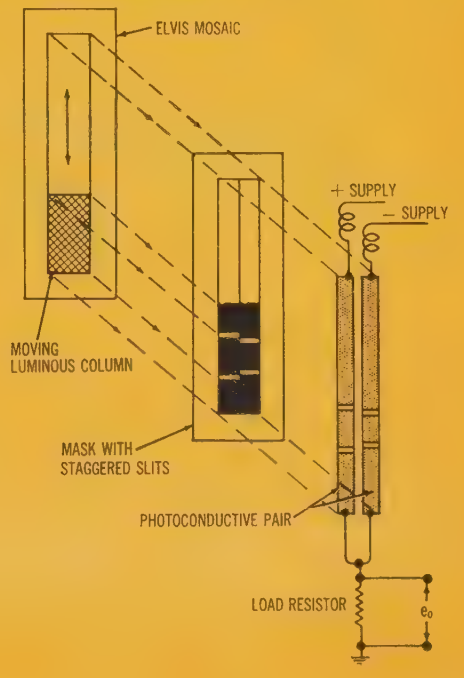


FIGURE 7: As the light column rises in this Elvis analog-digital converter, a positive output, zero, and a negative output voltage are produced in succession. With closely spaced apertures, output could be made truly binary.



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. . . WHERE RESEARCH IS THE KEY TO TOMORROW

Simple chamber pivoting enough for Black Knight control

by **Christopher Dawson,** Associate Editor

THE BLACK KNIGHT is an HTP-kerosene research missile developed by the British government. It has been used for a number of experiments, including nose-cone re-entry studies, and upper-atmosphere research at altitudes up to about 600 miles.* As part of the British ballistic-missile program, it has also been used for the investigation of the control dynamics of a high-mass-ratio missile with a flexible structure and pivoting combustion chambers. By May of this year, nine successful firings had been made.

The basic design work on the Black Knight was done at the Royal Aircraft Establishment in Farnborough, while Saunders-Roe is in charge of production. The first-stage Gamma rocket engine is based on a combustion chamber designed by the Royal Powerplant Establishment in Westcott. Four of these engines were needed for the required sea-level thrust of 16,400 lb. Bristol Siddeley Engines developed the powerplant in its final form. To reach the velocities needed for re-entry studies, Black Knight has a solid second-stage rocket arranged to fire downwards.

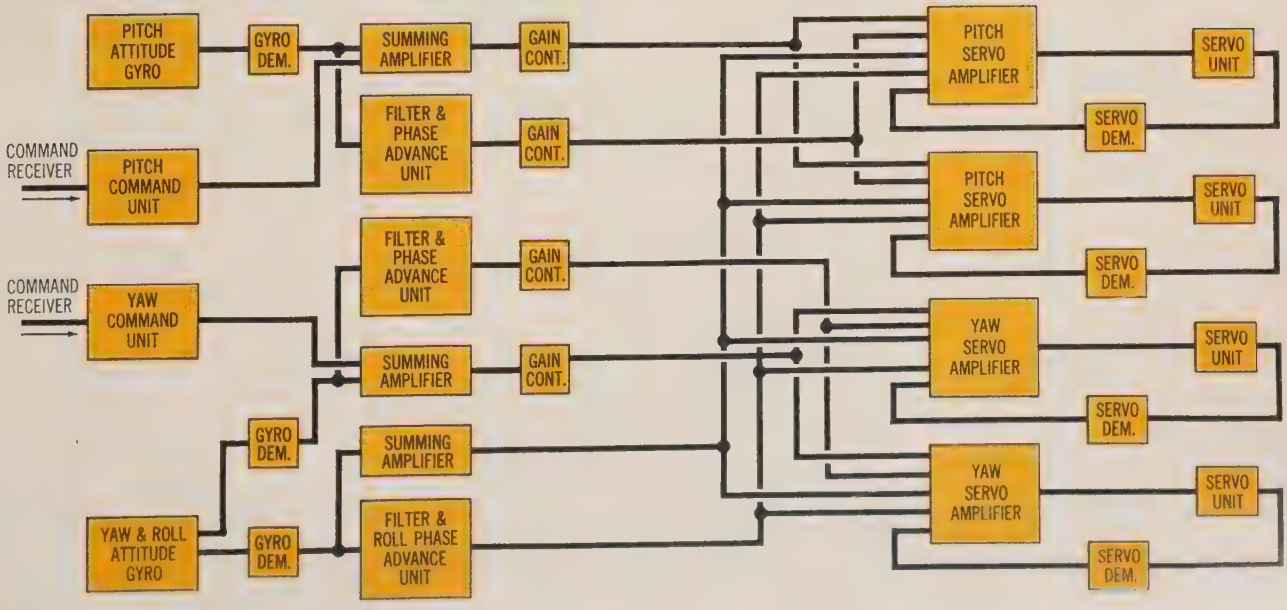
The use of four combustion chambers makes it possible to apply all control forces with each chamber

Finding parameters that insured stability without excessive angular chamber deflections was the basic control design problem for the Black Knight research missile. Four combustion chambers were used, an arrangement that provided all control forces with each chamber pivoted about only one axis. This set-up also simplified fuel and oxidizer supply and reduced control forces needed for a given response.

To correct deviations from the programed path, provision is made for optical and radar tracking. Corrections signals are sent over a radio link.

* H. G. R. Robinson, "Black Knight Control;" Rocket Propulsion Symp., Cranfield, England, Jan. '61.

CONTROL SYSTEM of British Black Knight research missile.



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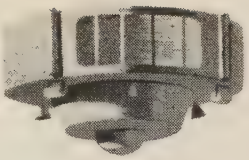
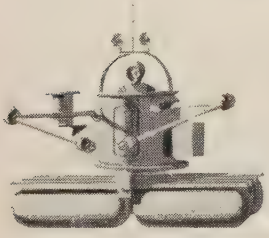


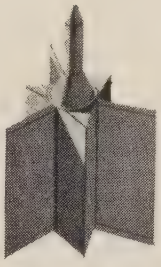
Lunar VTOL Vehicle. A rocket-propelled craft designed to collect lunar ore specimens.

Nuclear Space Ship. A Douglas design for a space ship with crew quarters and control rooms in the nose, nuclear reactor in the rear.

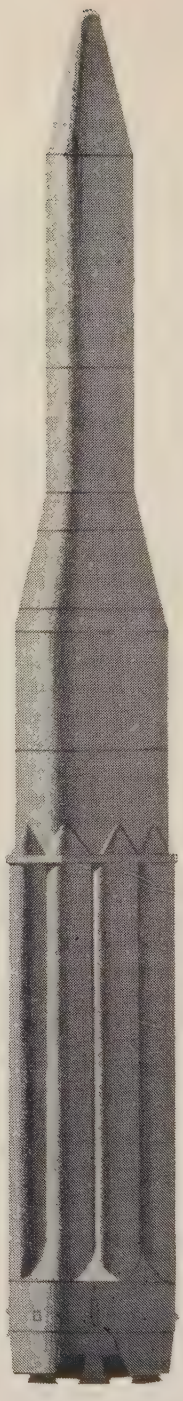


Lunar Service Vehicle. Travels like a "swamp buggy" on inflated rollers. Mechanical arms provided to handle outside chores.

Douglas Thor. Designed as a military IRBM, this dependable missile is the workhorse of the Space Age.

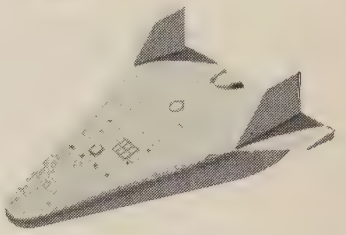


Nuclear Space Ship. A future, medium-thrust, nuclear-electric space ship for one-year interplanetary round trips (Martian and Venusian).

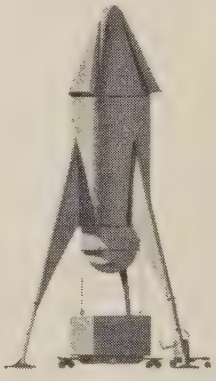


Saturn. First U.S. vehicle designed to put tons of payload into orbit . . . or onto the moon. Douglas-built second stage is as tall as a 4-story building.

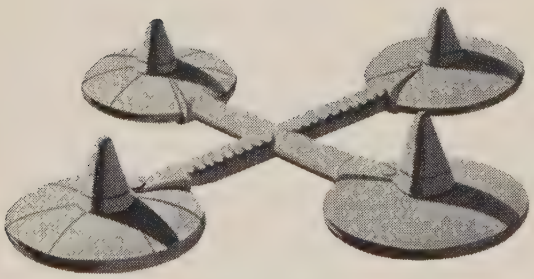
Nuclear Space Ship. An unconventional design by Douglas with living quarters around the ring at the bottom. On landing, it would ease down, ring first.



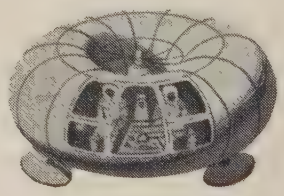
Supply and Escape Vehicle. A compact re-entry vehicle to supply orbiting space stations or to return crews to earth.



Lunar Cargo Handlers. Would load lunar ore samples into containers to be towed back to earth by rockets.



Space Observatory. Sections of this Douglas-designed space station would be sent into space in rockets and be joined together in orbit.



Lunarmobile. Donut-shaped exploration vehicle to use rocket power in space and tractor treads on the moon's surface.

Eleven ways to outwit the law of gravity

When the Space Age dawned, Douglas was ready with specific proposals for space equipment either completed or in advanced stages of development. (Some appear above.)

These Douglas proposals were based on *realistic* estimates of the capabilities of men and materials. They are the valued dividends of the company's considerable experience, gained from the design and production of 30,000 missiles and rockets. These include the Douglas *Thor*, an IRBM which has been totally successful in 86% of its tactical and space firings over the past two years.

Today, Douglas looks ahead to other exciting challenges from its firm position of leadership in the conquest of Space.

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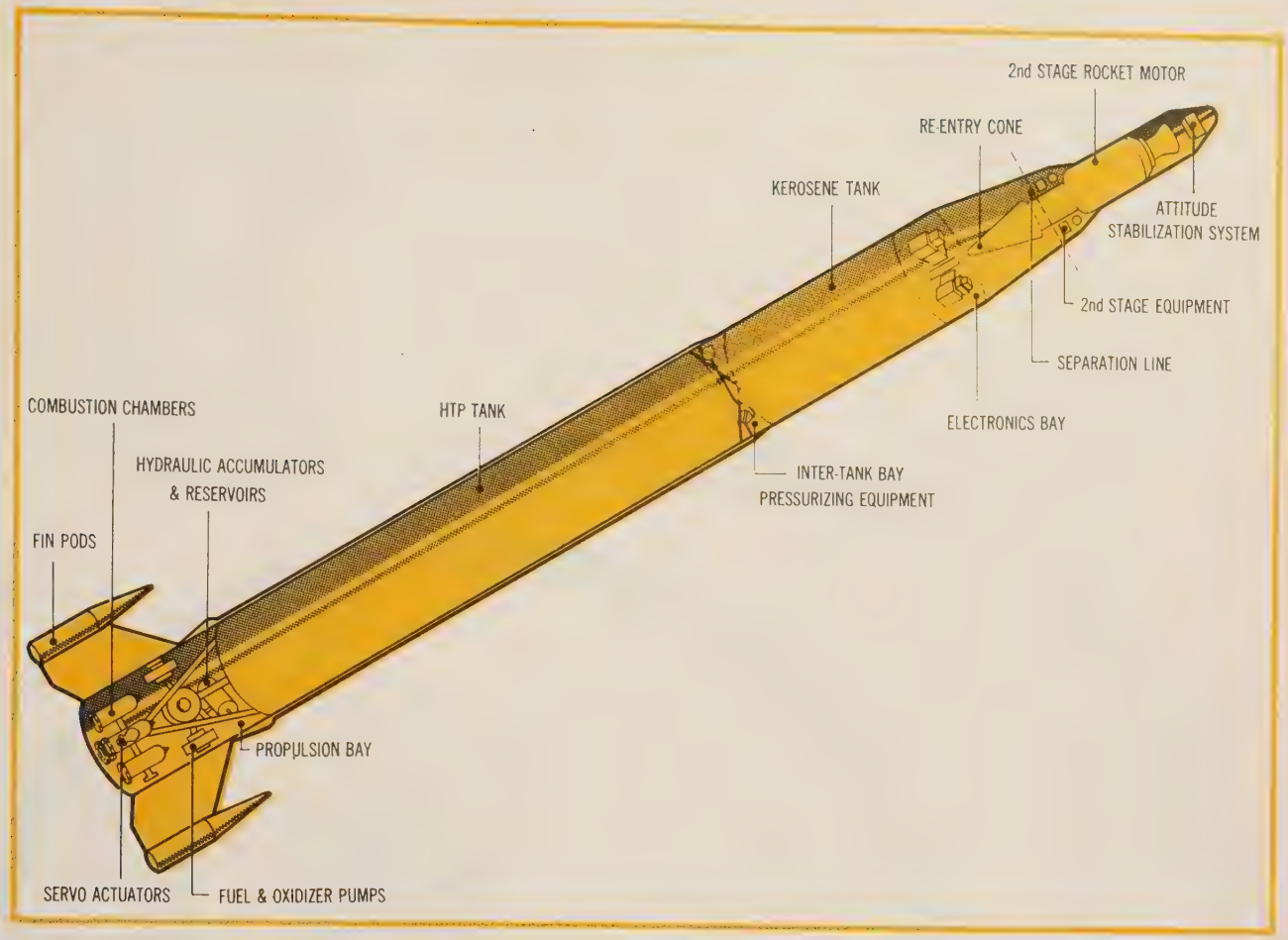

LAYOUT of two-stage Black Knight. The missile is about 37½ ft long overall.

pivoted only about a single axis. (The same, of course, would be true of a three-chamber layout.) Bristol Siddeley took advantage of the resulting simple arrangement and carried the fuel and oxidizer lines through the chamber mounting trunnions. The chambers also could be supported at their CG, which reduced the control forces needed for a given response. The Black Knight control system can deflect the chambers at 10-30 cps, and stabilization can be achieved at appreciably lower frequencies. Considerable weight is saved in comparison with a gimbal mounting system.

The chambers are swiveled by hydraulically actuated push-pull servo jacks that are modified versions of an earlier RAE design for a moving-wing actuator. The jacks are controlled by hydraulic spool valves operated by Laws relays.

Fins help with stabilization

Like many other Black Knight components, the hydraulic pumps are adaptations of an existing and well proven design — a Plessey high-speed gear pump delivering pressures of up to 4000 psi. Pressure-loaded bearings maintain pump efficiency over a wide temperature range. Two of these pumps are mounted on two of the four turbo-pump units supplying propellant to the combustion chambers.

The hydraulic system is a recirculating design, with a reservoir and a high-pressure accumulator for high transient loads. Non-return valves make sure that operation continues if one pump fails.

The control signals for the hydraulics come from the autopilot, which is housed far forward in the pressurized instrumentation and electronics compartment. Two Reid & Sigrist gyros give heading references — one in pitch and the other in yaw and roll. Any datum error in pitch, yaw, or roll (from the valves set on the launcher) produces a proportional angular chamber deflection. Damping of the resulting weathercock oscillation is derived from a bandwidth-limited, passive differentiating network in each circuit. These circuits are filter and phase advance units. Gain controls are provided in the yaw and pitch circuits. They are varied with time from launch to allow for the large changes in the moment of inertia and the aerodynamic derivatives as the missile climbs into thinner air and the fuel is used up.

Pickoffs eliminate sensitivity

The vehicle is roll-rate stabilized. AC Roehr pickoffs (with demodulators) are used in preference to potentiometers for both gyro and combustion-chamber position sensing to eliminate sensitivity to vibration and contact friction.

Because of range safety and instrumentation requirements, the Black Knight should impact within a target circle of ten-mile radius. The constant-heading auto-

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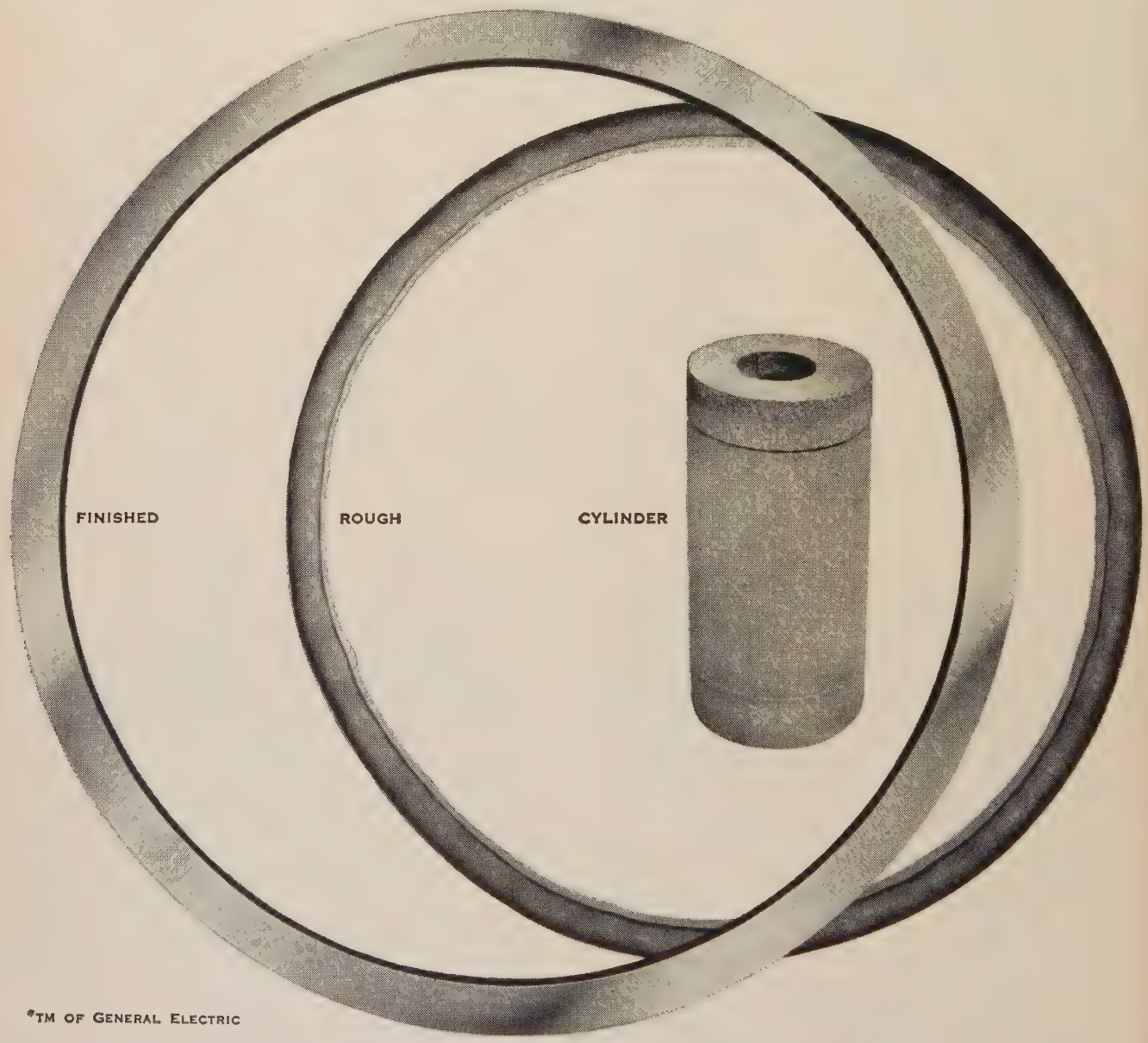

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pilot system alone cannot be relied on to give this kind of accuracy. Deviation from the required path before burnout is the main source of error, and this deviation in turn may be caused by wind, gyro datum setting errors at launch, control-loop bias, chamber thrust inequalities, and aerodynamic asymmetries. Gyro drift and winds pose the worst problems. To counter them, provision is made for optical and radar tracking and for the injection of guidance signals into the autopilot circuits.

Flares assist optical tracking

The first, vertical phase of flight is monitored by optical trackers with the help of flares on the rocket. The two trackers define planes at right angles. Deviations from the desired vertical path are displayed as both position and velocity errors on the guidance console. The necessary corrections are made by manual pulsed commands over a radio link. The command signals are fed into the autopilot summing circuits (aft of the gyros) as electric perturbations, or biases, and change the gyro heading datum.

The second phase, which lasts until burnout at about 80 miles altitude, begins at some 20,000 ft, when the missile enters a radar beam inclined along the desired path. The rocket carries a transponder to make tracking easier. Error correction is the same as for the optical tracking phase.

The basic design problem was the establishment of the control circuit parameters to ensure stability while avoiding the use of unnecessarily large angular chamber deflections (to lessen the problems of interaction with flexural modes of the structure). To help with stabilization during the early, atmospheric phase of flight, fins (without control surfaces) are fitted. Al-

MOVEMENT about a single combustion chamber's axis can give complete control only if there are three or more chambers. Even a swiveling single chamber cannot provide roll control without some auxiliary device.

Major breakthrough for missile secondary injection guidance systems

This AiResearch ultra-high temperature shutoff valve has been tested at 6000°F. Its development makes possible the use of secondary injection thrust vector control for greater simplicity and reliability.

This high temperature capability is an extension of previous AiResearch valve and controls experience in the —423 to 2000°F range, and further demonstrates over-all capability in the design of complete missile and ground support systems.

An inline poppet valve of extremely clean design has been produced to handle the high speed flow of hot, contaminated gas ducted from the combustion chamber to the exhaust nozzle. This design will: (1) keep lodging of contaminants to a minimum; (2) reduce turbulence and uneven wear; and (3) permit only a small pressure drop across the valve at maximum flow.

Growth into high temperature ranges can be accomplished by changes in material without changes in the basic valve design. The extreme compactness and light weight of the valve make it ideally suited for installation in the isentropic spike of a plug nozzle.

• *Please direct inquiries to Control Systems Project, Phoenix Division*

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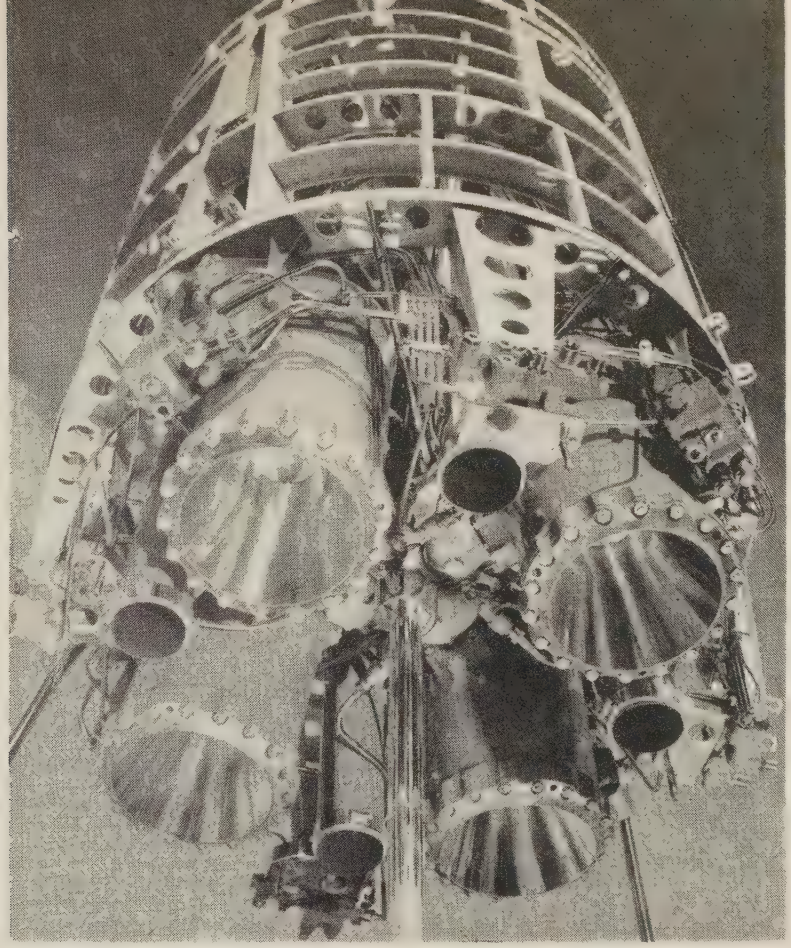


GAMMA POWER plant and engine bay of the Black Knight. Engine diameter is 36 in. Hydraulic actuators for chamber pivoting are carried on the outer trunnions. The pivot axis is approximately radial, with the chamber axes toed out somewhat.

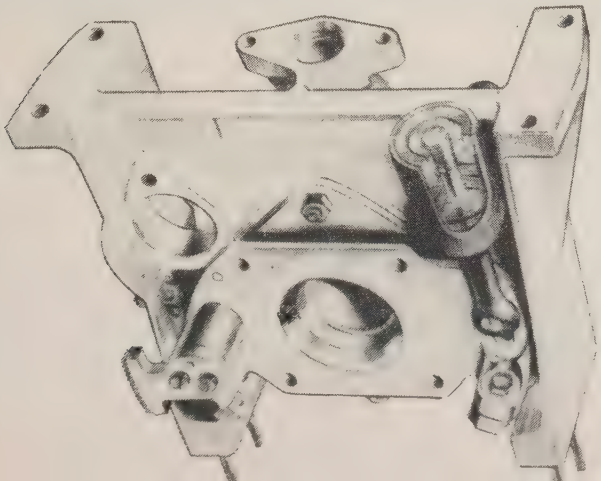
though weight considerations ruled out fins large enough to make the vehicle aerodynamically stable, the frequency response is reduced and the servo frequency bandwidth requirements are limited. Even with the fins, chamber deflections of five degrees to counter wind shear have been telemetered. Much greater deflection obviously would have been needed without the fins.

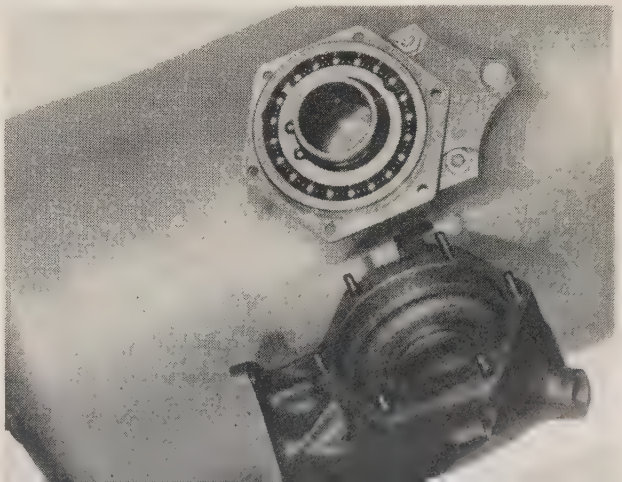
Structure has mass ratio of 10

To achieve its mass ratio of 10, the Black Knight has a very light structure. The bending and torsional vibration modes approach the frequencies needed for stable control of the vehicle. The desirable criterion that the servo break frequency should not exceed half of the frequency of the fundamental structural mode was not in fact achieved.

The design parameters and filter network characteristics we determined in a system study of the entire range of flight variables. Fuel slosh effects were also investigated, and the analysis suggested that little damping was necessary. Damping fingers are in fact fitted — they protrude inwards from the tank walls in spiral rows in the region where the liquid surface was expected to be when slosh effects appeared likely to be most critical. Flight tests later showed that full stability could have been maintained without the dampers.

FUEL TRUNNION mounting for Black Knight combustion chamber (left). Crinkle washers in cylinder at top right are buffer in case of overshoot. Right: Other side of chamber carries HTP trunnion bearing housing.





New IBM computer language...AUTOPROMT cuts milling time for this helicopter gearbox cover by 75%

AUTOPROMT (AUTOmatic PROgramming for Machine Tools) is a powerful new computer language designed to broaden the use of numerically-controlled machine tools.

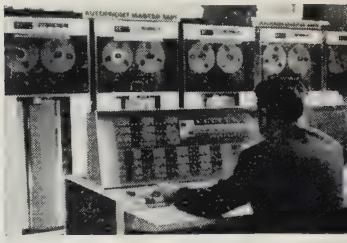
AUTOPROMT, for the first time, lets an engineer *describe the surfaces* of the three-dimensional shape he wants milled, *rather than calculating every path* the tool must follow in order to machine the part.

AUTOPROMT leaves to the computer the task of automatically generating these tool paths. You describe the part to be milled and the tool to be used in simple, *English-like*

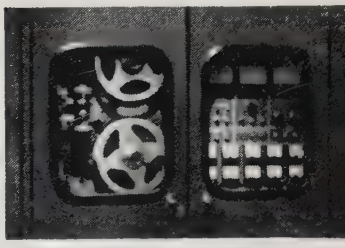
Here's the way AUTOPROMT works at United Aircraft Corporation

The Parts Programmer, using a conventional blueprint, prepares 180 one-line statements in AUTOPROMT language.

The statements are punched into standard IBM cards and entered into the IBM 7090 Data Processing System. (AUTOPROMT also works with the 704 and 709 Systems).



The 7090, programmed with AUTOPROMT, produces 8000 tool path instructions needed to direct the Pratt and Whitney Co. Inc. Numeric-Keller Continuous Path Milling Machine.



Punched tapes direct the Numeric-Keller Milling Machine.

The Numeric-Keller mills the helicopter gearbox cover.

erms. The computer does the laborious calculating work.

AUTOPROMT produces results like these: the time to mill he gearbox shown in the photographs cut to *one-fourth* the machine time required by conventional methods. AUTOPROMT reduced the lead time from blueprint to production *from three months to two weeks.*

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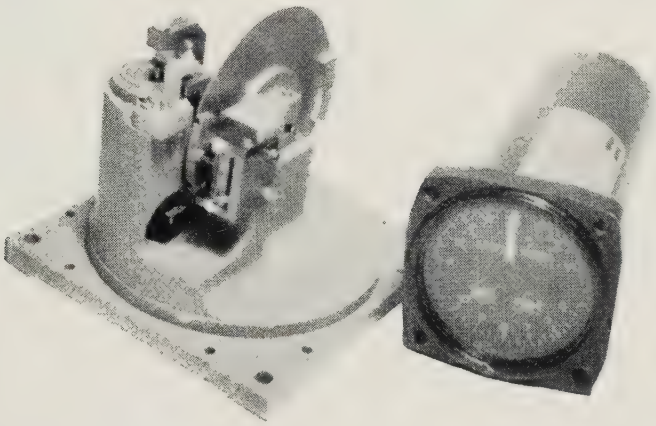
Radioactive testing

of accelerometer takes two large facilities

by Dale C. Baker, Staff Engineer,
Transducer Div., Giannini Controls Corp *



ACCELEROMETER used in nuclear-environment with cover removed (left) and its remote indicator (right).

How do you test a dynamic instrument that must operate in a high-temperature nuclear radiation environment? More specifically, what facilities and techniques are necessary for testing and how does a radiation environment affect criteria for materials, configuration and insulation?

These are just a few of the questions instrument designers must answer as they grapple with the new requirements of nuclear environments. Some of the answers can be gleaned from this review of a recent nuclear test series run on an accelerometer.

DESIGN SPECS required Giannini Controls' special accelerometer for nuclear environments to operate with a specified accuracy and sensitivity at 300 deg C for 100 consecutive hours in each of two radiation environments:

- a gamma dose of 4.3×10^8 ergs/gm (C)/hr;
- a reactor environment of 10^{11} fast neutrons per cm^2/sec (at $E > 2.9$ mev) and the associated gamma dose.

The accelerometer has a range of -4 to $+10$ g and a 400-cps signal output whose amplitude varies with the magnitude of the acceleration and whose phase changes with the direction of the acceleration.

The first test was run at Wright-Patterson AFB, Ohio, where the instrument was subjected to gamma radiation from a 17,000-curie cobalt-60 source. The second test was run at Ft. Worth, Texas, in Convair's three-megawatt nuclear reactor, which provided the neutron and gamma environments.

Because the first test used Co-60 gamma radiation, the centrifuge system and accelerometer we had used for it could also be used for the second test. This gamma radiation did not induce radioactivity. For the second test, however, the instrument and the test equipment had to be put into "hot" storage to let the induced radioactivity decay. The decay time—many months and possibly years—makes all test equipment as well as the test specimen almost useless for further service.

Commercial centrifuge can't be used

Commercial centrifuges, readily available for routine accelerometer testing, couldn't be used for nuclear testing. Common oils and greases polymerize under irradiation and cause moving parts to "freeze." Slip

* Transducer Div., Giannini Controls Corp., 1600 S. Mountain Ave., Duarte, Calif.

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He's one of a staff of AMF engineers which has been designing and producing precision radar antennas and components since early in WW II. AMF's accomplishments reflect the team effort, enormous experience and complete fabrication capability made available for each project.

Here are highlights:

Fixed base—AMF's experience in designing automatic machinery was utilized in the 10,000-lb. AN/FPS-19, the famous "Dew Line" antenna, designed and built by AMF to operate unfailingly under fantastic arctic conditions.

Mobile—AMF designed and built AN/TPQ-10 precision tracking antenna that demounts into shock-resistant, immersible components. AN/MPS-4 and 16 are AMF-designed trailer and truck-mounted types.

Stabilized base—Design and fabrication of SX, AN/SPS-8B High Gain Antenna, AN/SPS-3 Dual Foster Scanner.

Precision pedestals, theodolites—AMF's Precision Instrument Mount is controlled by optical digital discs accurate to 0.05 milliradans. It tracks missiles and satellites.

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Scanners, Feeds, Servos and *Drives,* Multichannel Phase Shifters, Hydrostatic Bearings, Slip Rings, Programming, Test, Control and Display systems are all part of AMF's radar capabilities. AMF also operates its own test ranges.

For more information, write American Machine & Foundry Company, Government Products Group, 261 Madison Avenue, New York 16, N.Y.

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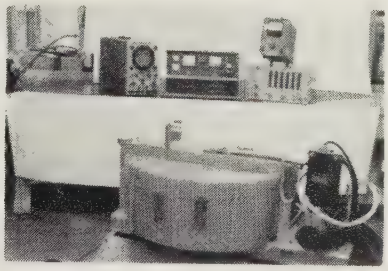

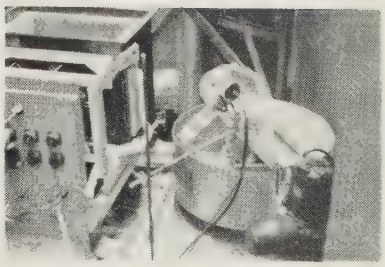

CENTRIFUGE as set up before installation in reactor for neutron radiation tests (left, control console in background) and for gamma test (right).

rings must have at least four times the normal applied potential rating to avoid arc-over caused by the high ionization of the nuclear atmosphere. Thermocouples must use the practical wire diameters to minimize errors due to gamma heating. The electric insulation, too, must be radiation-resistant.

Furthermore, as the expected radiation level surrounding a nuclear powerplant is extremely high, equipment must be operated by remote control and must have remote readout. In our specific case, operation of the entire assembly at the required 300 deg C would have imposed a number of practical difficulties, and we therefore decided to maintain only the instrument at this temperature while the rest of the assembly operated at ambient temperatures.

For the tests, we designed a special centrifuge with the help of Gyrex, of Santa Monica, Calif. It measured only 24 in. in diameter, since the accelerometer itself is small, too. Its speed range was zero to 222 RPM, and it was driven by a 208/220-V, AC, three-phase motor through a variable-speed transmission. The accelerometer, therefore, revolved at an effective radius of 9.24 in. and a maximum linear acceleration of over 15 g.

The centrifuge boom was enclosed in a steel tub covered with steel wire mesh, which served as protection against parts that might break loose without hampering the observation of boom rotation. The vertical shaft of the centrifuge was fitted with five pairs of silver-alloy slip rings (for instrument power transmission and signal readout) and one pair of heavy-duty slip rings (to conduct electric power to the instrument heater).

The variable-speed transmission, powered by a small, reversible motor through a gear box, permitted the operator to change the boom speed remotely. Boom speed (in RPM) was measured by counting pulses generated by a 600-tooth wheel as it moved past a magnet. This wheel was attached to the lower end of the vertical shaft.

The boom had a counterweight at one end and a fixture to hold accelerometer and heater at the other. Near the center of the boom was a small, 28-V DC motor with an eccentric mass mounted on its shaft. This device was used to induce the natural vibration that would occur during normal operation of the accelerometer. A hundred feet of multi-conductor cabling connected the centrifuge to the remote control console.

Slip ring leads fed to remote console

The remote console contained the start and stop switches for the drive motor, a variable transformer to control the instrument heater, the remote indicator for the accelerometer, increase and decrease switches for the speed-changer motor, an on-off switch, a voltmeter for the 400-cps instrument power, and an ammeter for the heater current. All leads from the five pairs of slip rings were tied to terminals on the front of the console.

The heater, modified to snugly enclose the accelerometer, was a 660-W unit made by Glas-Col Lab. Its outer aluminum cover was insulated with a ¼-in.-thick layer of a mixture of powered asbestos and sodium silicate, which was needed because of the strong cooling effect of the centrifuge's rotation.

The heater proved very efficient, maintaining an instrument temperature of 300 deg C at maximum rotational speed at only 80 per cent of the full voltage. An iron-con-

stantan thermocouple was placed between the instrument cover and the heater and connected to one pair of slip rings, which had enough brush tension to prevent noise.

In the ASD gamma irradiation facility, the hot cell was equipped with a 14-ft-deep well filled with de-ionized water. Small pellets of Co-60 were stacked in ½-in. aluminum tubes that were about two feet long. These tubes were arranged in three concentric circles about the axes of a right circular cylinder and held at top and bottom by metal plates. The whole assembly could be lowered to the bottom of the well with an elevator when the Co-60 source was ont in use.

The hot cell was equipped with the usual remote handling equipment. The three-foot-thick concrete wall had two windows of plate glass, with a bromide solution filling the space between the glass panels. Power and signal cables were led through the concrete wall by means of lead plugs with spiral grooves. The remotely controlled centrifuge was placed on the floor of the cell near the edge of the wall. After preliminary checkout, all personnel left the cell and the cell door was closed. When the Co-60 source was raised from the well to a position just above floor level, the test was ready to start.

Readings were taken every hour

The accelerometer was brought up to 300 deg C, and the centrifuge was energized. At specified RPM levels—corresponding to two, four, six, eight, and ten g—the accelerometer indicator values were noted. Readings of this type were taken every hour during the working day. At night, the centrifuge was set at some random RPM and allowed to operate unattended. This test was continued for 78 hours. The accelerometer was then tested for another 82.4 hours at room temperature.

At the end of the test, the Co-60 source was lowered into its well, and the test equipment was removed. Examination of both centrifuge and accelerometer revealed no visible damage or deterioration, even though the average accumulated gamma dose was 4×10^8 ergs/gm (C).

The next step was to run a similar test in Convair's combination dry and "swimming-pool"-type re-

Rockbestos Firezone Aerospace Wire Resists Jet Engine Heat in B-52

Rockbestos Firezone Type 101 Aerospace Wire is used for power and control circuits in the B-52 jet bomber, renowned for its high performance and dependability.

Dependability is designed into Rockbestos Aerospace wire too. In jet aircraft Rockbestos Wire resists the high temperatures around engine and afterburner sections. It is also used for high impedance circuits in guided missiles.

Standard Rockbestos Aerospace wires cover a temperature range from 257°F to 750°F. Many special wires have been produced to operate at even higher temperatures. In addition to high temperature aerospace wire, Rockbestos supplies hook-up wire, coaxial cable, and ground support cable.

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The Uses of Space

Man is the searcher. He has a driving urge to know. After centuries of speculation, ve now know that the world of space is infinitely more vast even than in our dreams. How shall we rise to the challenge of space knowledge? Ask any cientist and he will tell you: space is not something to be conquered but to be used--for reconnaissance, instant world-wide TV and radio communications, veather forecasting and basic research. Where will it all end? It never will.

own above is one feature of Republic's Space Environment and Life Sciences Lab- atory, largest space chamber in the nation capable of testing men and space sys- ms at simulated altitudes of more than 150 miles. Republic's new Research & velopment Center is the only fully integrated industrial research complex engaged every vital area of space investigation. Eight laboratories comprise the Center: ace Environment and Life Sciences; Re-Entry Simulation; Materials Development; clear Radiation; Electronics; Guidance and Control Systems; Fluid Systems; Transonic, personic and Hypersonic Wind Tunnels. Behind Republic's record of military aircraft ccess is the idea of man as the "irreplaceable element." This same concept is the sis of Republic's wide-ranging exploration of every field of space knowledge.

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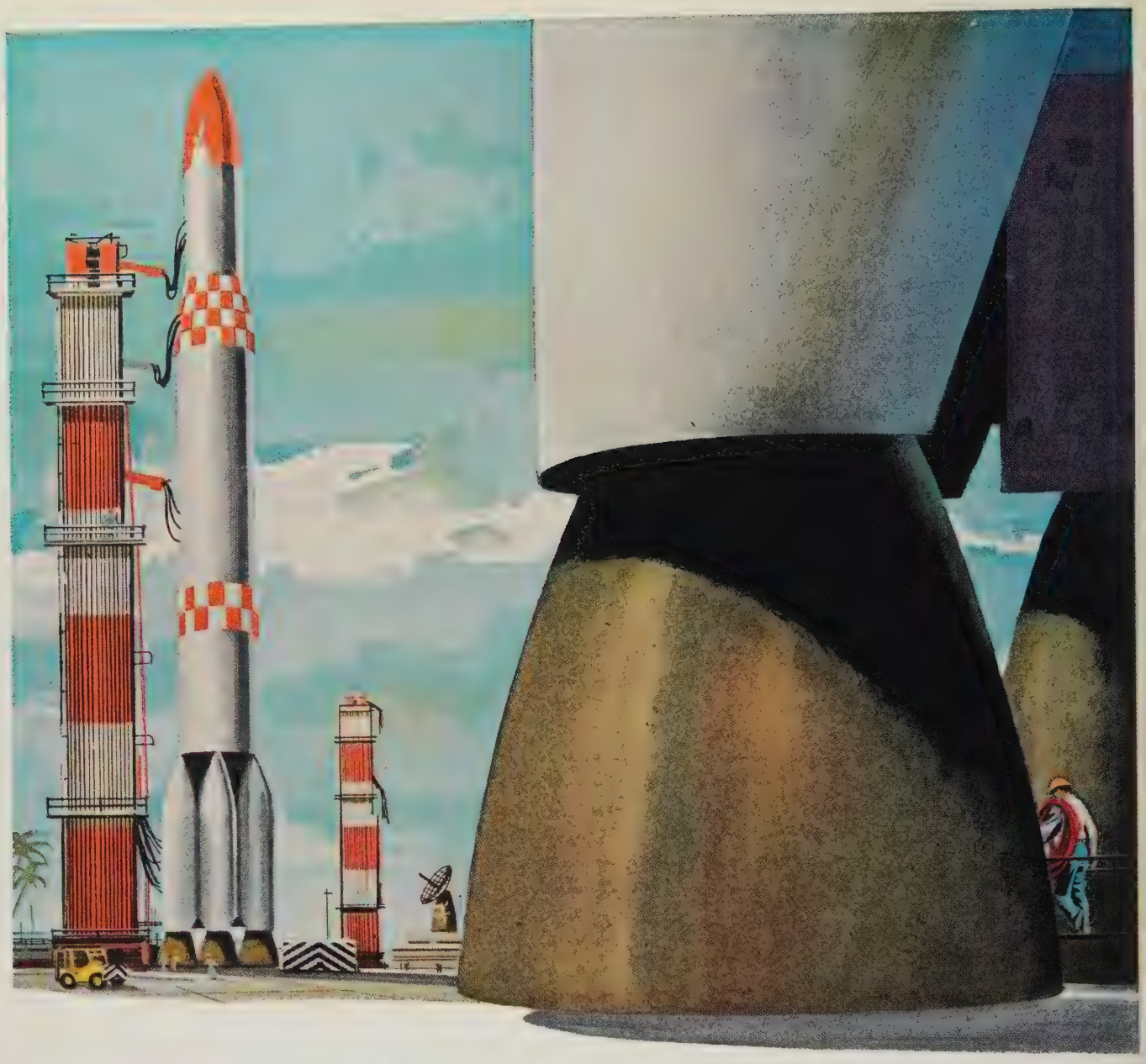


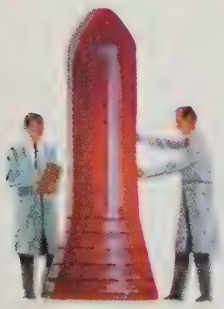
THE BIGGEST PLASTIC ROCKET NOZZLES ARE FROM HITCO

Coming... rockets that will dwarf—in size and thrust—every preceding launching. The plastic components that will gird them for flight will be manufactured to standards only recently considered impractical.

The Dumont Division of HITCO has advanced the art of molded plastics to this capability in the brief period of four years. Now, under HITCO, a combined team of engineers and technicians has made technological breakthroughs in both insulative and ablative plastics. New tooling techniques have been developed; the Dumont hydroclave can put pressure of up to 6500 psi uniformly on the surface of a reinforced plastic part. Dumont and HITCO are currently molding rocket engine components at pressures up to 30,000 psi.

Though giant rockets are still in the planning stage, the *giant plastic capabilities are here today.* HITCO is ready *now* to fit the biggest rockets with the biggest plastic nozzles.

HITCO-developed ablative materials and fabrication techniques are also providing Atlas and Titan nose cone heat shields. These materials enabled the first ICBM nose cone recovery.



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actor, which provides a maximum of three megawatts for continuous operation of 100 hours or so. The reactor is laid out so that equipment can be placed in three different spots next to the reactor core. Low pallets on rails are loaded with the test specimen and then drawn into position at the reactor core by means of steel cables. About 100 ft of power and signal cables are needed to lead from the test system through the handling area and then a water trough in the concrete wall of the control room to the test bench.

After the accelerometer was positioned in the reactor core, the reactor was started and brought up to 0.5 Mw for one hour. During this time, the dosimetry was done, the centrifuge energized and the boom rotated at about 20 rpm.

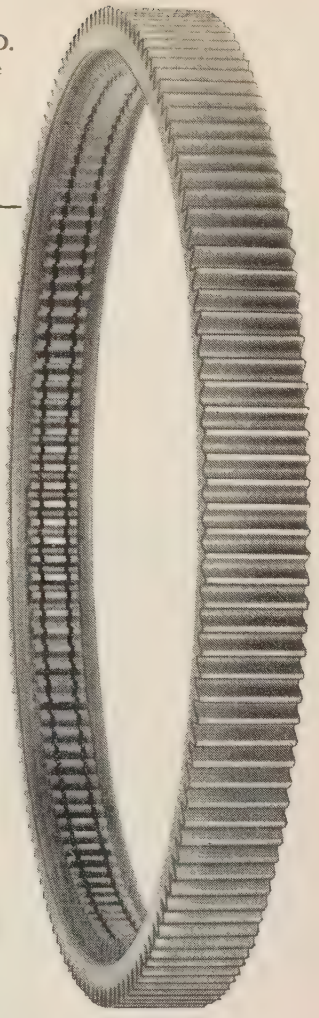
Equipment had acquired induced radioactivity

At the end of the dosimetry period, the pallet was withdrawn so that the ion gages and dosimetry materials could be removed. Trained technicians had to work very carefully, because the equipment at this point already possessed some induced radioactivity.

With the pallet returned to the test position, the reactor was brought up to full power. The accelerometer temperature was increased, and the centrifuge was energized. Every hour, accelerometer indicator readings were recorded at zero, two, four, six, eight, and ten g. Between the hourly readings, the centrifuge RPM was varied randomly. The test proceeded around the clock for a total of 94 hours. (The full 100 hours could not be logged because we could not get enough reactor time.)

Except for one failure, the test run was perfect. Part-way through the test, the speed-changer motor on the centrifuge transmission failed while the boom was rotating at a speed corresponding to slightly over two g. As the whole system was highly radioactive by this time, repair was impossible. For the rest of the test, we took a zero-g reading every hour by turning the centrifuge drive motor off. Turning it back on gave a 2.1-g reading. These two data points continued to show good repeatability, so the test was considered successful. At the end of the test, the whole system was removed and put in "hot" storage to let the radioactivity decay.

Snap-ring grooves in this 12" O. D. thin-section *Reduction Drive Gear* are machined before carborizing and hardening. Both spline and gear teeth are ground and held to .001" excentricity after hardening the entire gear.



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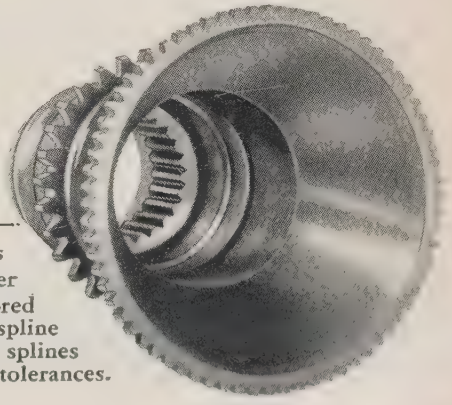

Most machining operations on this *Drive Gear Shaft* are performed after localized hardening with the cored areas at Rockwell C42. External spline and gear teeth are ground with splines held to precision tolerances.

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RYAN RESEARCH VEHICLE SPEARHEADS FLEX WING APPLICATIONS

With the world's first manned Flex Wing vehicle, Ryan engineers are uncovering valuable new flight data which will adapt this concept to a broad variety of important military and space applications.

Recovery of huge boosters, nose cones and capsules... re-entry of space vehicles at reduced velocities ... helicopter tow of logistics payloads... controlled delivery of air-dropped cargoes to "pin-point" landings... small reconnaissance drones to meet combat needs. These are a few of the multiple applications for which the Flex Wing can be used.

Based on a National Aeronautics and Space Administration concept, the Flex Wing provides greater lift per weight than fixed wings, is superior in inherent stability and can be precision-controlled in both powered and unpowered versions. It can be packaged into an extremely small volume and then deployed faster than any other deceleration or lifting devices.

Ryan Flex Wing enables helicopters to tow several times the cargo or fuel they can carry

Ryan has received several contracts from NASA and the military services to explore and develop the more promising Flex Wing applications. Pioneering an entirely new concept, such as Flex Wing, is typical of Ryan's Space Age capabilities.

Ryan Aerospace – Ryan Aeronautical Company, San Diego, California.

RYAN AEROSPACE

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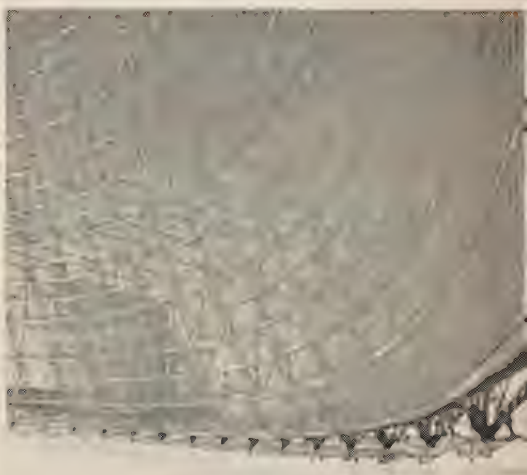
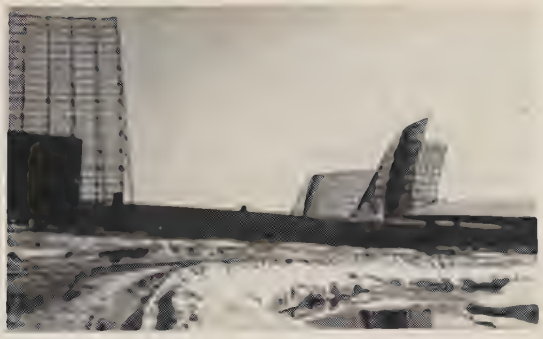
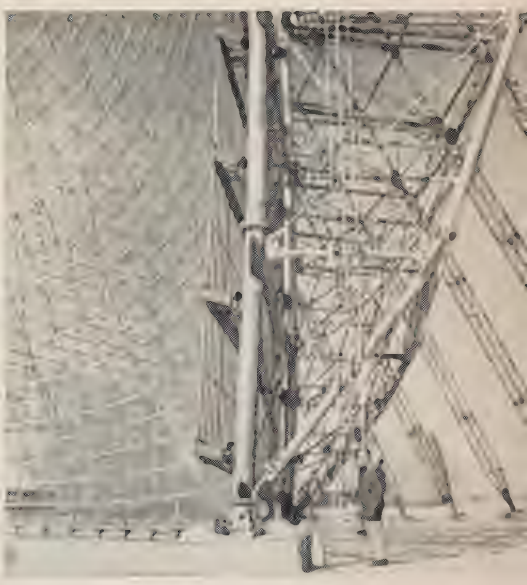
AUGUST 1961

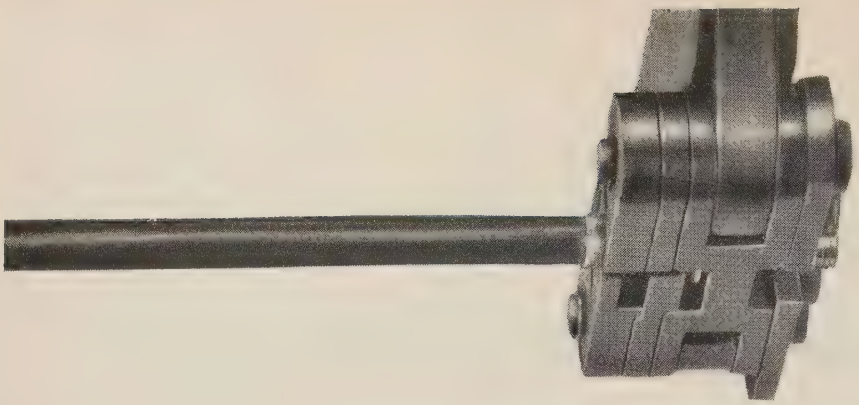
aerospace electronics







THREE giant torus radar reflectors stand as mighty sentinels in the northern wastes of Clear, Alaska to guard against surprise attack from enemy ballistic missiles. Part of BMEWS soon to be fully operational at Clear, the antennas were made by D. S. Kennedy & Co. to General Electric specs. Made of special nickel steel, each reflector is 165 ft high and 400 ft wide. Design deviation of reflector elements in a 60 mph wind and ½ in. ice load is 2.2 in.



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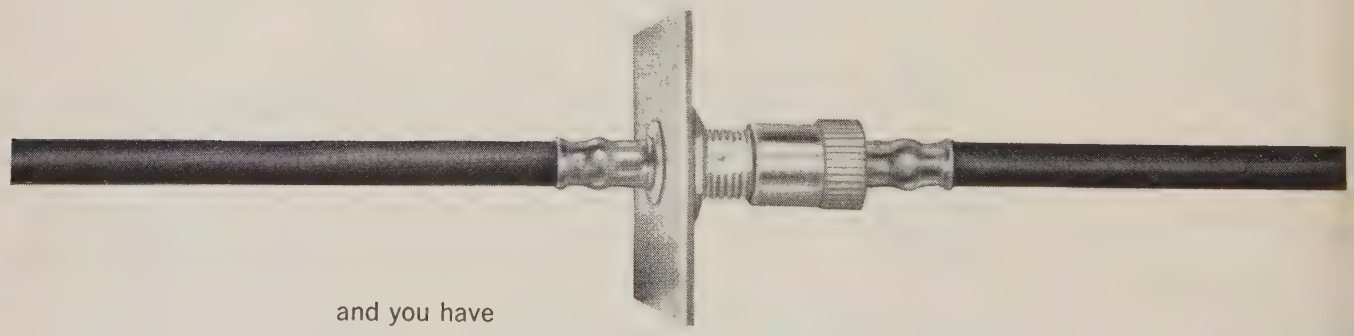

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ADVENT PROGRAM WILL PROVIDE FEASIBILITY DATA ON MILITARY MICROWAVE-COMMUNICATION SATELLITES

Advent synchronous communications satellites will be active repeater types built by GE's Missile & Space Vehicle Department. They will be launched first into test orbits much lower than the planned operational 22,300-mile synchronous orbit. Atlas-Agena Bs will be used for the test orbits and Atlas-Centaurs for the operational orbits.

The prime purpose of the Advent program is to provide R&D data on the feasibility of a military microwave communications satellite system. Two ground tracking and terminal stations at Fort Dix, N. J., and Camp Roberts, Calif., will be developed and installed by Sylvania. A third station will be installed on a Navy ship for tracking from ocean locations.

SYNCHRONIZED WITH EARTH'S ROTATION

The Advent satellites will have station-keeping equipment for adjusting their positions to remain synchronized with the earth's rotation. "A combination of propulsion, attitude control and tracking capabilities" will be used, says GE. The satellites' communications and telemetry antennas will be kept continuously pointed at the earth by a control system that gets its attitude data from IR horizon sensors.

Electrical power will be provided by a 28-V DC supply furnished by nickel-cadmium batteries charged by thousands of silicon photovoltaic solar cells. The cells will be mounted on two rotatable paddles and kept continuously pointed toward the sun, as sensed by a sun tracker.

External gas jets will provide the necessary impulse for station keeping, antenna alignment, and solar-cell orientation. The jet exhaust will be precisely aimed by the attitude control system of the vehicle. Signals will be emitted from the satellites for ground tracking and position corrections. In addition to the microwave communications repeater equipment, the Advent satellites will carry telemetry gear for reporting data to ground tracking stations and for receiving signals in return.

The satellites and their electronics are being designed for a mean operating life of one year without failure, according to GE-MSVD, which has systems responsibility for the payload. To meet this figure, individual systems are being built to a goal of 20,000 hours (almost 2½ years) of continuous operation, says GE.

The spaceborne communications gear will be built by Bendix Systems Division. The Advent temperature range will be —460 to 260 deg F.

ADVENT WILL RESTART TWICE IN SPACE

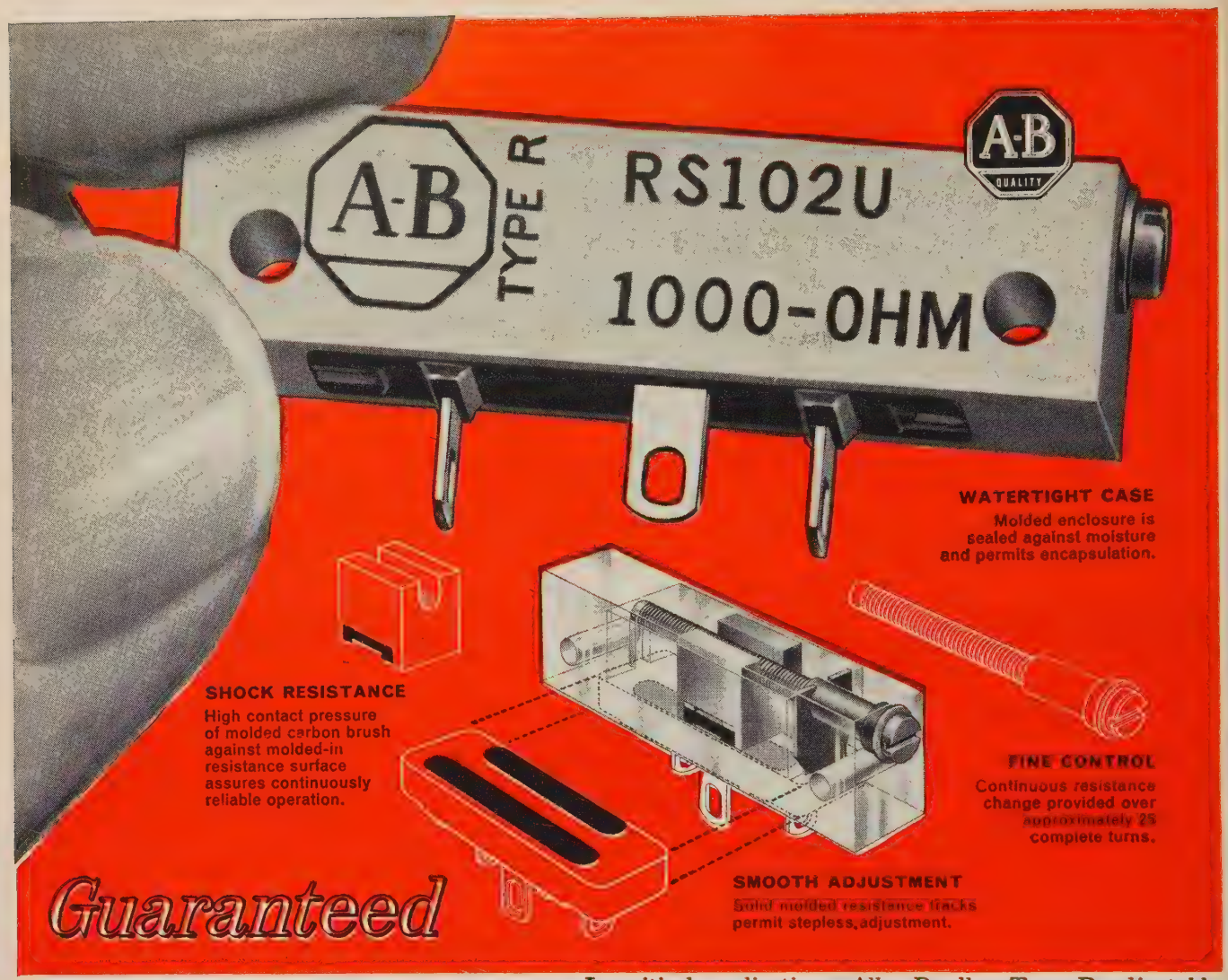
No weight figures have been given out on the Advent payload or on the power output of the communications transmitter. The Atlas-Centaur reportedly could put about 1000 lb into the synchronous orbit. It could first go into a 300-mile "parking" orbit, shutting down thrust, and then re-ignite for a predetermined period to reach an orbit of about 22,300 miles. Here it would shut down while it determined its exact position. Then it would restart for the second time to make final speed and altitude corrections, and the payload would be ejected into the desired orbit.

The guidance and control requirements for this method of injection into a synchronous orbit are quite stringent and could pose a serious problem. The development of bigger boosters would simplify the guidance problem (provided the payload does not increase commensurately).

Commercial communications satellites will not make anyone a Croesus overnight, RCA Board Chairman David Sarnoff stated recently. He calculates that the international communications business of all the American carriers today amounts to about $135 million per year. In the seventies, with a satellite system in use, operating revenues might reach the $1 billion mark, he predicted, but they certainly won't reach the fantastic figure of $100 billion used by some industry forecasters.

Sarnoff also made three proposals for the commercial communications satellite effort:

- **A joint government-industry group should be set up to pursue an aggressive**



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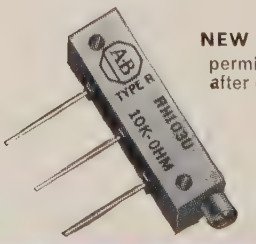
The molded case of the Type R control is watertight and dust-tight. Rated ¼ watt at 70°C, these Type R controls are available in values from 100 ohms to 2.5 megohms.

**Test Report #71801, Sept. 1960, United States Testing Company, Inc.*



NEW CUP GUARD
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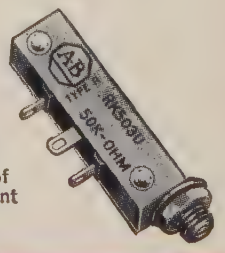
permits front of panel adjustment



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QUALITY ELECTRONIC COMPONENTS

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overall R&D program.
• Satellite ownership should be regarded as less important than the "adoption of the right system" at the earliest possible moment.
• Regardless of who and how many may own the satellites, all present and future organizations licensed by the government to operate in international communications should have direct access to the satellites, which furthermore "should be available to all such organizations on reasonable and non-discriminatory terms for any services which the FCC authorizes . . . "
Private enterprise rather than the government will own and operate the commercial communications satellite system, President John F. Kennedy decided, following the recommendations of the National Space Council.
The decision in favor of private ownership was subject to several stringent conditions:
• The system must provide global coverage, including service to unprofitable areas of the world.
• Opportunities will have to be provided for foreign participation through ownership "or otherwise."
• Equipment for the system must be bought on the basis of competitive bids.
• The ownership and control structure must insure maximum competition.
• The system must be economically justified, and any economic benefits must be applied to cutting overseas communications rates.
• "Equitable access" to the system must be offered to all authorized present and future communications carriers.
• Anti-trust legislation and regulatory government controls must be fully complied with.
• New and expanded international communications services must be made available at the earliest practical date.
The President did not decide what kind of companies can participate in the ownership of the communications satellite. He may be leaving this question to the Federal Communications Commission, which has made it clear that it favors companies that are already in the international communications business. This would exclude equipment makers like GE, Hughes Aircraft, and Lockheed, three companies that have said they would like to own a piece of the system.

Attempts at Britain's Jodrell Bank facility to track the Russian Venus probe failed, but they did show that more scientific interchange between the USSR and the free world is possible. After a week of trying to confirm whether radio signals received at Jodrell Bank's 250-ft radio telescope came from the probe, it was concluded that the vehicle by then either was off course or had stopped transmitting. Prof. Alla Masevitch, head of the Russians' tracking service, and Dr. Khodarev, who had worked on the Venus vehicle, both traveled to Jodrell Bank to trace the probe.

RUSSIANS GAVE COPIOUS DETAILS

The Russian scientists gave the British copious details of the vehicle and its equipment as well as of their ground equipment. They said the probe carried a reserve transmitter programed to send identification and telemetry data for 90 minutes at five-day intervals and also to transmit on demand. Command signals were transmitted from Russia, but no return signals could be detected. The British scientists at Jodrell Bank told SPACE/AERONAUTICS *that, if the Russians statements on their tracking gear are correct, they have better equipment than anything in Britain and probably better than anything in the U. S.*

CW RADAR GUIDANCE EXTENDS BLOODHOUND 2's RANGE

British Bloodhound 2 surface-to-air missile system, recently selected for Sweden's air defense, will have continuous wave radar guidance. According to Bristol and Ferranti, who developed the Bloodhound. the CW radar will extend the missile's range beyond that of the Mk 1 version and make it possible to use the missile against both very-high and very-low-altitude targets, (even in the face of highly sophisticated electronic countermeasures). The new Bloodhound version is in an advanced stage

Only 1-1/2 ounces (including the switch plate)

Heinemann's new Series VP may well be the lightest circuit breaker made. For sure, it's one of the smallest and most compact you'll find around. Yet, remarkably, it's capable of handling all the functions of much larger Heinemann breakers.

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It is available with a choice of time relays. You can have either a "fast" or "slow" delay. Or instantaneous response.

It can be furnished with any of Heinemann's special-function internal circuits. With a little ingenuity and a special circuit, you can make the breaker do such out-of-the-ordinary chores as remote switching, circuit "slaving," alarm signaling.

The matchbox-size Series VP is available in any integral or fractional rating you might need, from 0.050 to 15 amps (at 110V, 60 or 400 cycles AC, or 50V DC).

Bulletin VP will give you detailed specifications and dimensions. A copy is yours for the asking.

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SA 2460

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of development, having gone through highly successful test firing in Britain and Australia.

New CW gaseous IR maser successfully demonstrated by Raytheon's Research Division uses a combination of helium and neon gases to produce a coherent 1.15-micron output. Similar in principle to the CW gas laser shown a few months ago by Bell Labs, the Raytheon device has several novel features and a simplified design. It is designed so that critical parts can be removed and replaced easily. The entire structure is mounted on a low-expansion Invar rod frame and weighs 35 lb. The gaseous discharge takes place in a Pyrex tube.

DIGILOCK TELEMETRY RADICALLY CUTS POWER NEEDS

Digilock telemetry developed by Space Electronics for USAF's Special Weapons Center attains a communications efficiency in watts per bit that approaches Shannon's theoretical lower limit. Where a +20-db S/N ratio used to be required, Special Weapons Center engineers say, a −12-db S/N will suffice with Digilock. In terms of power, this means that a conventional 400-W transmitter may be replaced with a ¼-W Digilock transmitter.

The flight package contains a seven ounce, 2.5-in.-diameter, two-inch-high solid state transmitter (made by Vector Mfg.), a 4½-lb Digilock encoder, and batteries. The encoder accepts 100 binary bit inputs in groups of five and transforms them into 16-bit Digilock words for transmission.

The ground receiver is a Nems Clarke 1401B RF unit modified by the addition of Space Electronics' phase lock converter. The tracking loop bandwidth is 10 cps; the information bandwidth, three kilocycles.

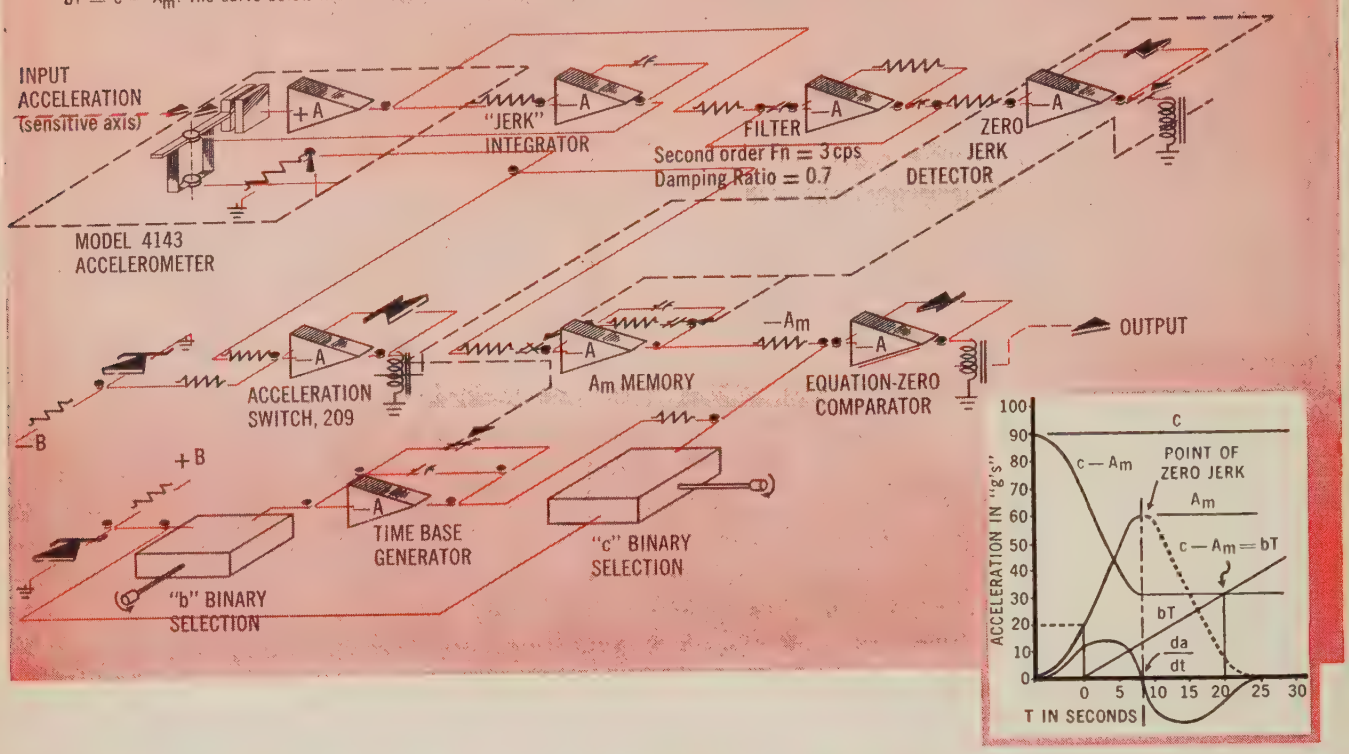
TRANSISTOR FAILURE RATES FIT WEIBULL DISTRIBUTION

Transistor failure rates are not constant but vary with time in such a way that they fit the Weibull distribution, engineers at Motorola Semiconductor Products concluded after running transistor tests under 27 different operating conditions over a period of millions of unit transistor hours. The use of the Weibull distribution paves the way for more accurate evaluation of transistor reliability data, results in a high degree of confidence, and allows smaller samples, the Motorola group believes. The accuracy of the Weibull distribution predictions will make it easier for transistor manufacturers to include more meaningful reliability curves in engineering data sheets, it claims.

Toughened microwave communications system recently completed by Collins Radio for the operational Atlas ICBM sites around Fairchild AFB, Wash., is designed to stand an overpressure from ground shock waves of up to 25 psi. The system can provide a total of 480 three-kilocycle voice channels between the widely dispersed launch sites and the command post control center. The single-sideband-suppressed-carrier frequency multiplex system can be expanded to 600 channels and includes automatic fault sensing and re-route switching.
Equipment racks are installed 20 ft underground on specially designed shock mounts in concrete and steel bunkers. Four-foot antennas are used for most terminals; they are installed on concrete pedestals and protected by high-strength, ¾-in.-thick plastic radomes.

First solid-state S-band transmitter for space communications was designed and built by Sylvania's Amherst (N.Y.) Labs. The unit has an estimated MTBF of 14,000 hours, weighs about three pounds (including a copper block heat sink of one

Functional Diagram of Donner Accelerometer Timer Switch. Basically an airborne computer designed to solve a specific equation, this Donner device consists of a force balance accelerometer, whose output feeds to a jerkmeter for determination of peak acceleration (Jerk (da/dt) is the first derivative of acceleration). From the jerkmeter the signal passes through a filter and to a zero jerk detector which closes a switch at the peak acceleration. Other units in the computer are a peak acceleration memory, a 20 g acceleration switch which starts a time base generator and prevents the zero jerk detector from operating before a correct solution is possible, "b" and "c" selection binary units allow 64 values of "b" and "c" to be selected within the operating range, and an equation zero comparator which algebraically sums the output of the maximum acceleration memory circuit, time base multiplied by "b" and "c" circuit to close the relay output when $bT = c - A_m$. The curve below illustrates the equation and the fact that peak acceleration occurs at zero jerk.



How to Solve a Flight Equation

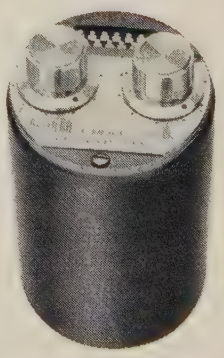
New Donner Airborne Analog Computer solves equation $bT=c-A_m$

where b = predetermined constant, T = time in seconds, c = predetermined constant, and A_m = peak acceleration achieved.

Causing a missile event to occur at just the right time and place in space is one of the critical problems faced by the control engineer. The programming device must be light, accurate, strong and, above all, reliable in severe environments.

When Donner engineers were confronted with this problem, they came up with a fixed purpose airborne analog computer known more specifically as an acceleration summing switch. The summing switch is a "thinking" device which responds to a particular environmental stimulus. Thinking for the vehicle, the switch measures time, multiplies it by a preset constant, equates the product to the memorized peak acceleration subtracted from a constant and when the sum reaches a predetermined value, actuates a relay. Such a point occurs during decreasing acceleration and is dependent on the magnitude of peak acceleration.

In solving this problem, Donner engineers combined their experience with computer techniques and servo force balance accelerometers. The device illustrated is all solid state.



Acceleration Summing Switch. This remarkable small computer is approximately 4" high and 2½" across. The two knobs on the top are used to set in "b" and "c" constants of the equation.

COMPLETE TECHNICAL INFORMATION AVAILABLE
If you would like more information about this interesting application of computer and transducer techniques, our Mr. Stephen P. Cuff has prepared a technical discussion which he will be happy to send along. Please write Mr. Cuff at Donner Scientific

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pound), and measures 6×3.4×2 in. It puts out two watts in the 1700-2300-mc band. The operating temperature range is —20 to 80 deg C. Single-sideband suppressed-carrier modulation is used.

BUILT UNDER USAF CONTRACT

Built under a $95,000 study contract from USAF's Aeronautical Systems Division, the transmitter is made up of a transistorized VHF exciter and a harmonic multiplier using varactors. The exciter feeds a 10-W, 187.5-mc signal to the harmonic multiplier, which has two doubler and one tripler stages.

Sylvania claims that, because it uses direct crystal control, its transmitter has about 10 times the frequency stability of conventional transmitters. The Amherst Labs had previously developed a miniature solid-state S-band receiver with a predicted life of 36,500 hours (See S/A, "Ultra-Reliability Can Be Built into Electronic Circuits," Jan. '61, p. 134).

The Helmet anti-ICBM program is in the earliest stages in government labs under the sponsorship of the Advanced Research Projects Agency, which hopes to develop a system to destroy attacking ballistic missiles in their terminal phase. The ARPA scientists and their consultants haven't yet decided just how Helmet would work. Turning their basic concept into hardware, they say, will require considerable advances in the state of the art in both lift capability and non-nuclear kill mechanisms.

The first radar track of a re-entering ICBM was made last September with a FPQ-4 C-band radar on the American Mariner missile tracking ship as part of ARPA's Project Damp (Downrange Anti-Ballistic Measurement Program). Two FPQ-4s are the prime tracking devices on the American Mariner. Modified RCA FPS-16s that were left over from the land-based-Talos program, they serve as "masters" to four "slave" instrument pedestals on the ship.

Atlas warheads have also been tracked through re-entry by Nike-Zeus target acquisition equipment based on Ascension Island.

Perkin-Elmer officially tossed its hat into the optical-maser ring at a company-sponsored symposium. Reportedly, it will fund its program in this field with $250,000 of its own money in the coming year.

OPTICAL MASER ULTIMATELY WILL BE THE MOST ACCURATE

John G. Atwood, director of research of P-E's Instrument Division and manager of the new program, pointed out that the optical maser, whose extremely high coherence and highly energetic, non-spreading beams allow interferometry at extremely long ranges, should ultimately become the most accurate ranging instrument. The present state of the art, he admitted, is quite crude. The ruby masers on which P-E is basing its present R&D program have very unpredictable characteristics. However, says Atwood, the users of optical alignment instruments should not let that keep them from putting forth requirements for instruments based on the extraordinary predicted capabilities of the device. He pointed out that much of today's troubles are caused by our lack of knowledge about how to get suitable optical quality in the ruby and how properly to control the stimulated emission.

WILL WORK OUT USES FOR LASERS

Atwood said that his program would concern itself mainly with trying to measure and deduce the working characteristics of the laser and with working out the applications to which various laser types would be suited (mainly in the alignment and ranging field). It's already fairly clear he stated, that optical masers, with their extremely wide beamwidth over enormous distances, will offer great advantages in aligning platforms, particularly in view of the greatly shrunken platform prism (now about 1×1¼ in., as compared to the 8-10-in. prisms in use only a couple of years ago). Also, the optical maser's sharp bandwidth means Doppler techniques are definitely feasible and the possibilities for background discrimination are enormously improved.

Atwood also suggested that optical masers might be used to advantage in the atmospheric windows in the IR portion of the spectrum. Some of these windows, he noted, are even more transparent than the visible region of the spectrum.

We like engineers who are never satisfied

Quality at Scintilla is more than a word—it's a positive attitude. We believe our electrical connector quality reflects our personal and business integrity. That's why engineers at Scintilla have the right—the obligation, actually—to say "no" to the smallest deviation in quality. We conduct continuous engineering research and development—seeking better designs and methods. We maintain one of the highest ratios of inspectors-to-production-workers in the industry. This close control over our electrical connector quality has done much to put us in a top position in an important market—and to make Bendix the brand most often selected for the most demanding jobs. We are confident our electrical connector customers will tell you that no company in the industry produces higher quality than does Scintilla. This acceptance, and our resulting volume, enables us to offer reliable product performance at prices that meet—or beat—any others. There's a lot more to be said on this subject of quality with economy. Give us a call!

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Provocative panel discussion on "Trends in Weapon System Development" was the highlight of the Fifth Military Electronics Convention in Washington, D.C. The panel was led by John Rubel, Assistant Secretary of Defense, and included the Assistant Secretaries for Research & Development of the three services: Dr. Brockway McMillan (USAF), Dr. James Wakelin (Navy), and Dr. Edward Witting (Army). All panelists were refreshingly frank and clear. Save for a brief recital of Navy "firsts" in electronics by Dr. Wakelin, they did not try to sell the attentive audience of some 1000 on the merits of their respective services.

Commenting on our ICBM program, Rubel told the group that, "had we somehow been wise enough to see the real requirement and the orderly ways to achieve it on a more timely basis, we could have deployed [ICBM] systems when we needed them with less frantic and quite probably less expensive effort."

DOD has sometimes been weak in advance planning and in deciding on definite requirements, Rubel admitted. The result, he said, is "that we have developed some things for which there proved to be no real and sensible need." He went on to point out that DOD has conducted many efforts "in a vacuum with insufficient regard for paralleled and competitive development. . . . Many of these efforts should have been canceled or redirected."

Rubel accused many of our system designs of "maldevelopment" and "tailfinism." The former he defined as the "development of a system that later proves unusable by troops or unmaintainable," the latter as overstated requirements (often due to engineering enthusiasm) that result in automation and miniaturization "beyond the point of diminishing returns."

A particularly dangerous practice on some of our systems has been to concentrate on the more challenging and exotic design aspects to the neglect of the more mundane engineering features, Rubel complained. The result is that many "edge-of-the-state-of-the-art" systems are beset by shortcomings that should be easy to avoid at the present state of the art.

Minuteman, Polaris, Titan, and Zeus were cited by the panel as accounting for 25-30 per cent of DOD's total research, development, and engineering budget. Together with the B-70 before it was cut back, these systems took up about 40 per cent of this budget.

The Army itself spends about half of its research and engineering budget on Advent, Mauler, Pershing, and Zeus. The Navy has $1300 million in its defense research and engineering budget, and is spending $450 million on Polaris, $200 million on basic and applied research, $100 million in support of the Pacific Missile Range and space projects, and some $450 million for exploratory R&D.

USAF's disenchantment with the prime-contractor for weapon systems was brought out emphatically by McMillan. "In the future," he said, "we [won't have] the money or time to squander on contracts that are misleadingly bid or improperly managed." USAF will do more in-house development of system specs and then turn these over to industry, McMillan stated. For electronic systems specifically, he said, "we shall rely on Hanscom [ASC's Electron Systems Division] to supply the systems direction and on contractors to make the hardware."

McMillan believes USAF's Ballistic Systems Division (formerly BMD) has the right formula in its use of nonprofit organizations (First Ramo-Wooldridge and now Aerospace) for technical and scientific advice on ballistic missile systems. He said all major USAF systems R&D will now follow this pattern with Aerospace Mitre giving the advice.

Though McMillan did not say so, it has been apparent that many USAF people have long been concerned over the large share of technical responsibility that USAF has ceded to industry. In electronics, for example, much of the technical planning even is handled by industry. One of the obvious drawbacks of this situation is that a prime contractor is not likely to be too objective—after all, he's in business for himself.

However, before USAF can do a reasonable in-house job of systems specifying, management, and planning it will have to re-staff its house to make up for the technical talent that has been siphoned off by industry.

Communications is one of Army's major problem areas, according to Witting, who said that communication has lagged behind fire power and that he would like to see a departure from present communications concepts—to something that would permit person-to-person contact by wideband transmission.

Reliability was the main theme of Wakeland, who contrasted the 80 electric switches, 45 electron tubes, and zero transistors carried in Chance Vought's F4U of World War II and Korea with the 276 switches, 340 tubes, and 360 transistors in C-V's F8U and the 541 switches, 680 tubes, and 13,900 transistors used in NAA'S A3J.

Two interesting points brought out by Witting were:

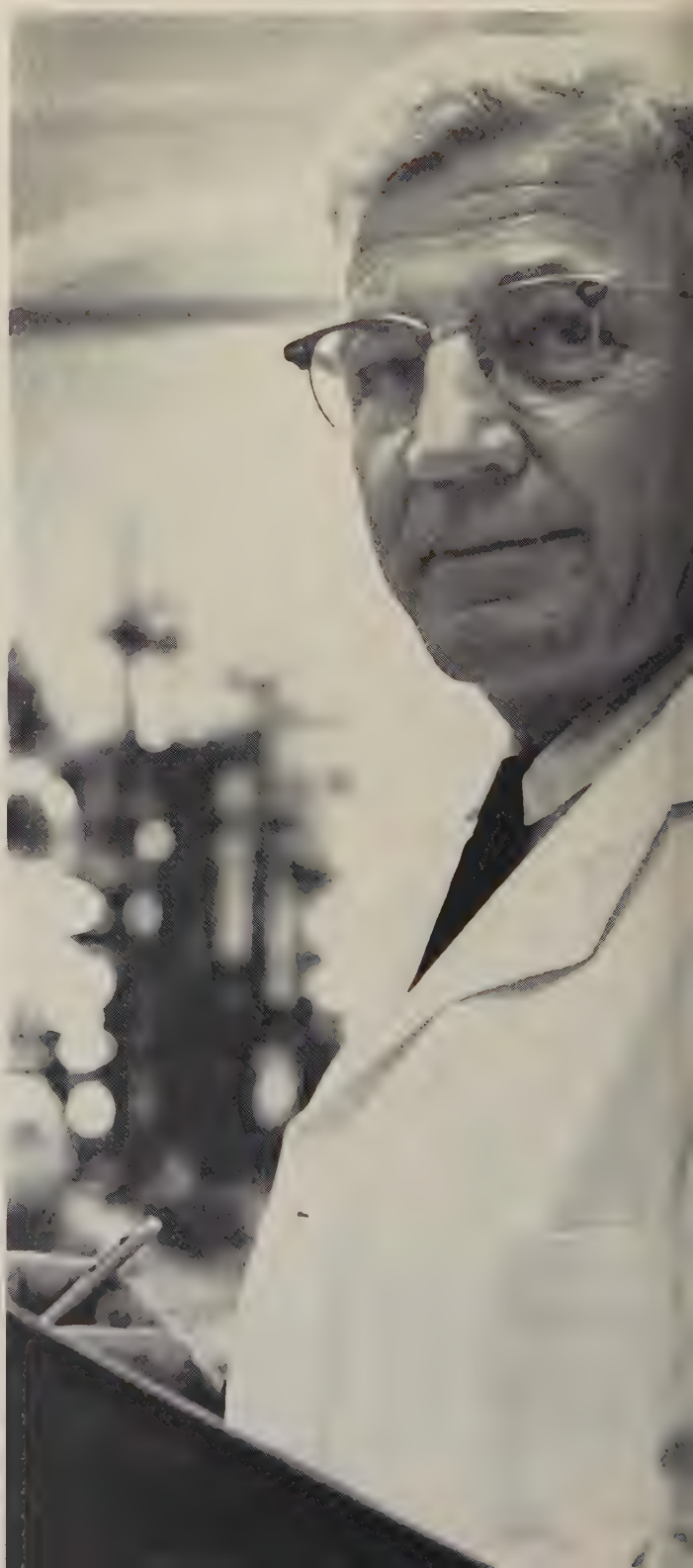
- The Navy is installing redundant magnetrons in many of its radars.
- The Navy's contract on the A2F-1 attack weapon system contains an incentive clause that gives the contractor an *additional profit* if he exceeds the reliability goal and imposes a penalty if the goal is not met.

Questioned whether they would be willing to sacrifice performance by going to simpler but more reliable electronics systems, both McMillan and Witting said no. Wakeland thought a tradeoff is possible between unrealistic performance goals and reliability, which may be as high as 50 per cent.

The panel concluded that we have done poorly on simplicity and reliability in our space effort. The trend has been to sophistication and complexity with little standardization. Each firing is a completely "new event," the panel members claimed, and little of what is learned from a firing is used to advantage later on.

The tendency of designers to strain for that "last inch of optimization" often creates a built-in unreliability factor, they added.

Almost all global strategists are enthused about



ystems using Sperry electronic tubes

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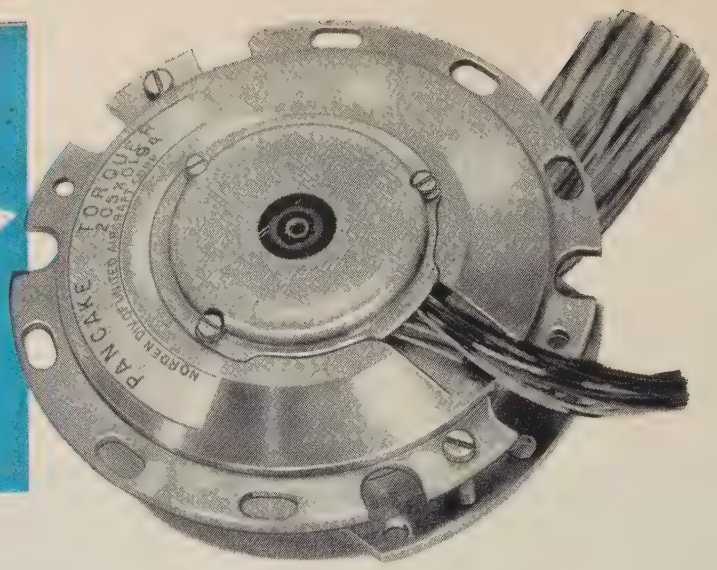

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Now you can specify compact, pretested packaged torquers and pick-offs, designed to the gimbals of your inertial system. Save valuable design manufacturing and testing time while retaining high reliability and precision of the system. Assemblies consist of either torquer or pick-off, slip rings and brushes, and high quality ball bearings. These units offer these distinct advantages:

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- Assembly is prealigned; bearings are pretested.
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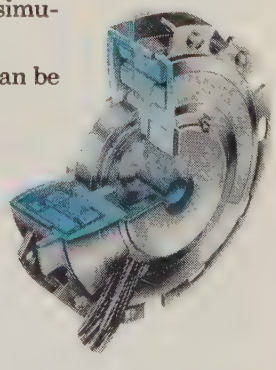
- Models are now in hardware—can be shipped ready for installation.



MECHANICAL CHARACTERISTICS

Slip Ring Data
(common to synchro, a-c torquer and d-c torquer)

Number of circuits	28
Voltage Rating (Hi-Pot) (400)	500 volts
Continuous	120 volts
Current Capacity (d-c)	500 ma
Noise Level (10rpm)	50 microvolts max.

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(common to synchro, a-c torquer and d-c torquer)

Ball Bearing Radial Static Capacity	300 lbs.
Ball Bearing Thrust Static Capacity	570 lbs.

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Input Power	0.5 watts
Accuracy (max. error from E. Z.)	±3 minutes of arc*

*±1.25 minutes of arc can be supplied

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Type	permanent magnet, fixed field
Peak Torque	5 oz-in.
Resistance	110 ohms
Max. input for linear operation	50 volts
Power Input at peak torque	8.5 watts

TYPICAL AC TORQUER GIMBAL PIVOT ASSEMBLY

	Fixed Phase (S1-S2)	Control Phase (S4-S5)
Voltage	26 volts	52 volts
Frequency	60cps	60cps
Power Input at Stall	8 watts	8 watts

Stall Torque at Max. Power Input . . . . . 3 oz.-in.

For further information including complete specifications, performance data and dimensions, call TEmple 8-4471 TWX NWLK 21, or write

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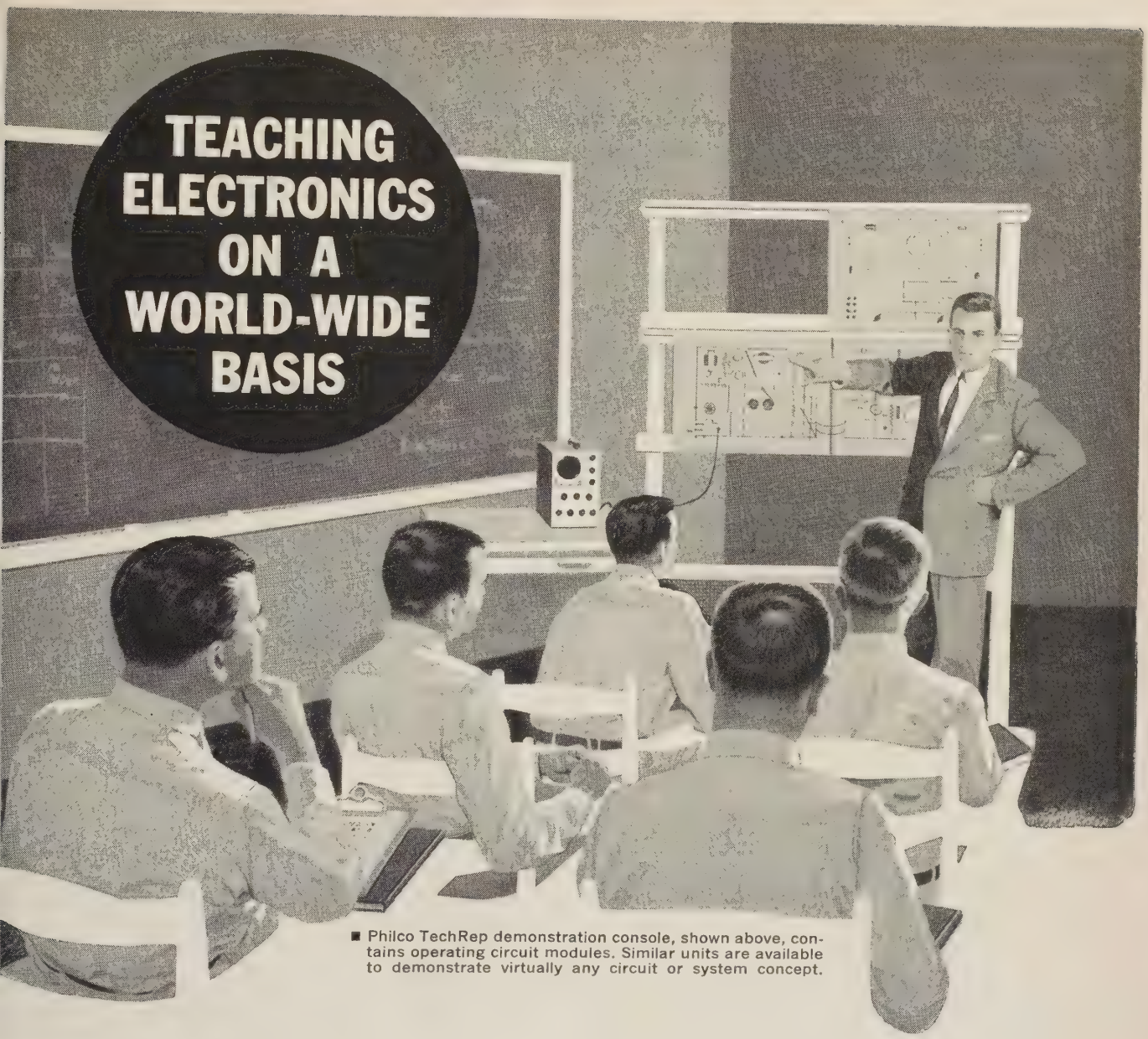

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This world-wide communication network will help Strategic Air Force leaders exercise command and control almost in response to events of the moment. Yet the forces involved are dispersed throughout the world, the volume and complexity of information unprecedented. ¶ The SAC Control System will be a product of the new technology of automated information processing assistance. We have helped create this new technology, beginning with our work on SAGE. In projects such as SAACS and SAGE, we perform system analysis, information processing system design, and training of personnel in system use. And as a continuing effort, we carry on research into future generations of these control systems.

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The globe shown is the Dymaxion projection by R. Buckminster Fuller. It depicts the spherical world as a flat surface with a minimum of distortion

Fractional Horsepower Motors

THE LATEST DESIGN NEWS ON FHP MOTORS FROM LAMB ELECTRIC

Lamb Thinking on Universal Motors for a unique actuator application

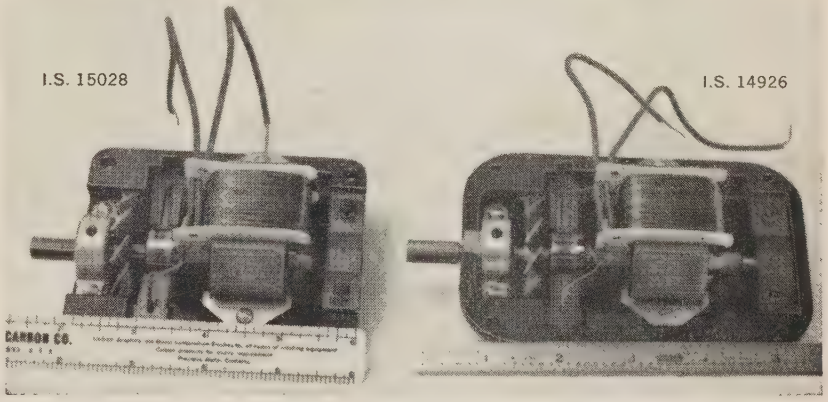
Here's what Lamb Electric designed into these motors:

In order to obtain the required speed and torques and retain the most economical and smallest package, a combination worm and spur gear reduction was used. Also, because of the peculiar space limitations in the application, special design considerations had to be given to the gear ratios and mechanical layout of the package.

In the initial stages of the design a motor was provided which met the specified speed and torque requirements, however it was soon discovered that this design overheated rapidly. Analysis of the first prototype tests showed that the load cycle had a particularly high torque peak for a very short duration. The motor was designed to supply this amount of torque near its stalled speed. It was found that by taking advantage of the accelerating rate and starting torque of a universal motor, the motor accelerated quickly enough to provide sufficient inertial energy to complete the duty cycle. This enabled the engineers to redesign for a lower peak horsepower output and obtain reasonable operating temperatures, thus producing the minimum size package consistent with the torque and temperature requirements.

The application was such that severe shock loading was encountered at a certain point in the duty cycle. In order to make mechanical construction that would withstand this service, ductile iron castings were furnished and special consideration had to be given to the overhung moment of the motor-gear unit to insure against damage due to vibration. Special bearings had to be used in this service because Brinnelling would occur on normal ball bearings under the severe service encountered. Lubrication is generally a problem under this short duty cycle, therefore, special consideration had to be given to insure that the lubricant protected the wearing surfaces at all times.

This is just a short example of Lamb at work . . . if you have a motor problem, let us help you with it. This is our business. Write: Lamb Electric, Kent, Ohio, and we'll have a Lamb District Engineer call on you to open preliminary discussion of your problem.



New Lamb motors represent advancements in small universal motor design

New design combines high quality and long life with relatively low manufacturing costs

Initially, the I.S. 15028 and companion motor I.S. 14926 were designed for powering rug agitators on a well-known line of canister-type vacuum cleaners. Now, many future appliance applications have been visualized. The range of ratings possible with this design (as high as 1/10 H.P. at 12000 RPM or ⅛ H.P. at 15000 RPM) makes this motor ideally suited for many motor powered domestic applications.

Some of the novel features of this motor project were:

The housing is a one-piece simple phenolic molding. It is designed in a half shell form in such a way that the motor bearings and other components can be held in accurate relationship with an unmachined housing.

The half shell housing of the motor is designed to mate with a corresponding opening on the customer's device to complete the motor enclosure. When a free standing motor is desired, this upper enclosure can be a simple stamping.

The I.S. 15028 motor was designed with a sleeve and a ball bearing. However, on other versions of this motor, either sleeve or ball bearings or a combination can be used at only a low tooling expense through use of easily interchanged inserts in the housing mold cavity.

The sleeve bearing as used in this design takes full advantage of the economics possible with the half shell motor design. The full-spherical shaped self-aligning type of sintered bearing is mounted directly in a semi-spherical recess in the housing. A spring clip presses against the top of the bearing to secure it in place while at the same time permitting self-alignment movement. Life-time lubrication is provided by an oil soaked felt strip located beneath the bearing. There are other features worth noting in this unique design problem. For further particulars, write to Lamb Electric Co., Kent, Ohio.

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Environment protection when it counts!

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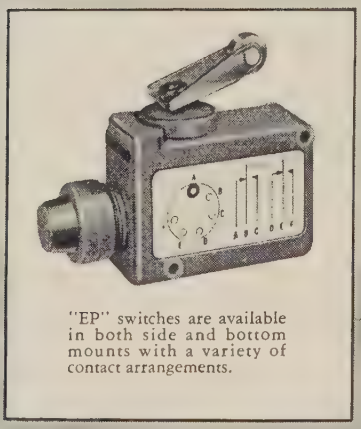
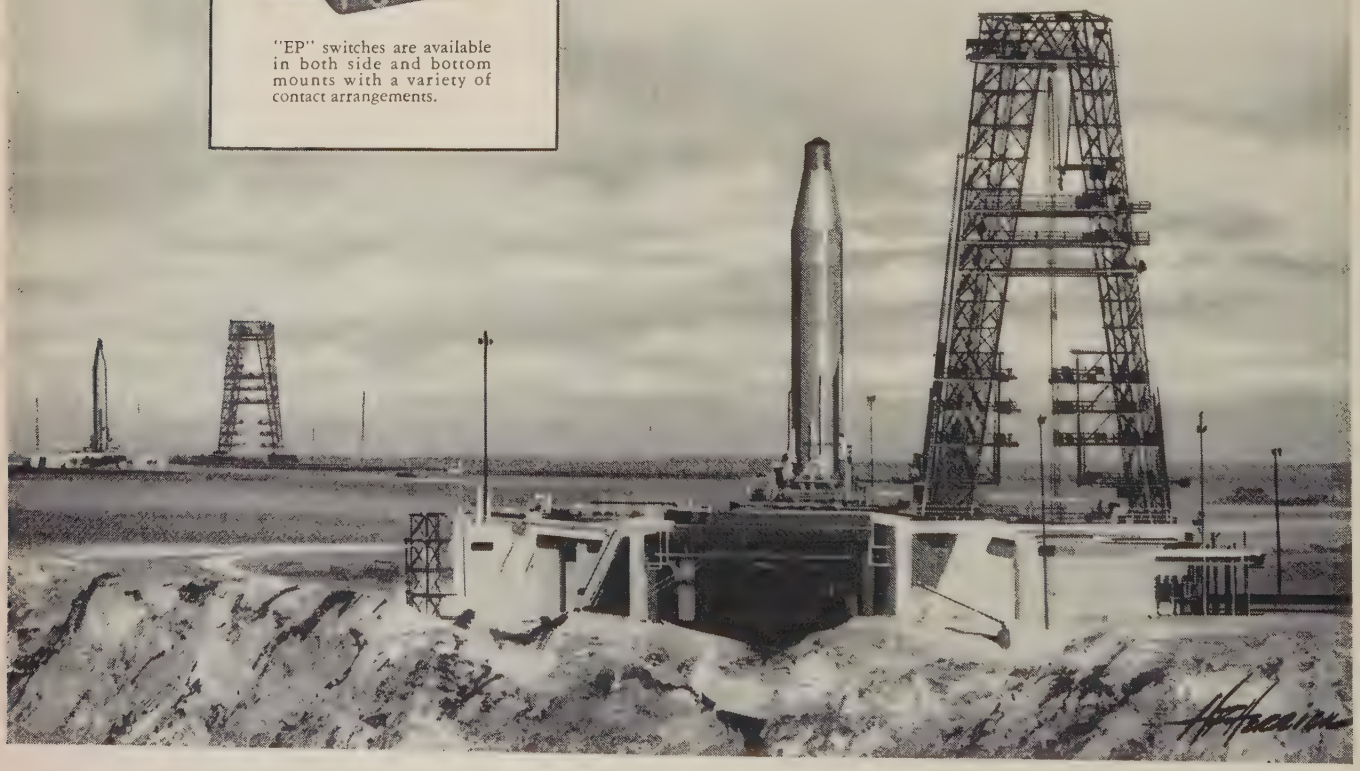


"EP" switches are available in both side and bottom mounts with a variety of contact arrangements.



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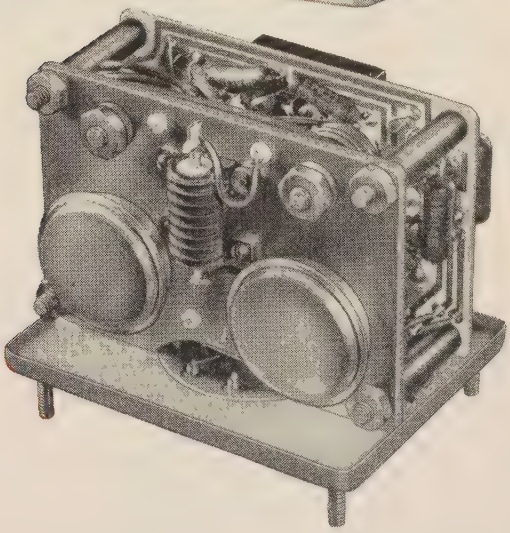

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Plasmas: circuit elements for future electronics?

by **James E. Hopson,** Physicist, General Telephone & Electronics Laboratories, Inc.*

One of the most remarkable properties of plasmas is that they can be used as dielectric circuit elements for electromagnetic waves that are propagated through them. Their dielectric constant depends on the frequency of the interacting electromagnetic field. By coupling electromechanical waves generated within the plasma with applied electromagnetic waves the latter can be amplified.

For the use of a plasma as a circuit element, the plasma characteristics and their reaction with electromagnetic fields must be understood. These characteristics vary, for example, with changes in the frequency of the applied electromagnetic field relative to the ion and electron plasma frequencies.

For calculations, a plasma model can be assumed in which only the electrons move, while the ions are stationary. Then, by accounting for all the forces that could act on the electrons, it is possible to solve for electron motion. This solution enables you to calculate the electron density, which is then inserted in the Maxwell field equations to provide quantitative data on how an electromagnetic wave propagates within a plasma. This procedure is analyzed for four different cases of electromagnetic-wave propagation in a plasma.

IN THE EARLY TWENTIES, Irving Langmuir applied the term "plasma" to the positive column of a glow discharge. As such a region is roughly electrically neutral, "plasma" has come to mean a wholly or partially ionized gas for which the densities of positive ions and negative electrons are roughly equal. However, small local inequalities in charge densities may occur as well as volume currents due to the motion of the plasma electrons relative to the plasma ions. It is these charge-density inequalities and currents that give a plasma its interesting electrical characteristics, including the ability to support and modify electromagnetic propagations.

These plasma characteristics depend on the frequency of the interacting electromagnetic wave. They fall into two general categories, depending on whether or not the ions move appreciably under the influence of an electromagnetic field:

- If the frequency of the electromagnetic field is on the order of the *ion* plasma frequency or less, then the ionic motion is appreciable and magnetohydrodynamic effects result.
- If the frequency of the electromagnetic field is on the order of the *electron* plasma frequency or higher, then the ions move hardly at all, and the major plasma effects are due to electronic motions.

The ratio of the ion plasma frequency to the electron plasma frequency is given by:

$$f_{ip}/f_{ep} = \sqrt{m/M}, \tag{1}$$

where m and M are the electron and ion masses, respectively. The electron plasma frequency is given by:

$$f_{ep} = 9000\sqrt{n}\ cps, \tag{2}$$

where n is the plasma electron density (in electrons per cubic centimeter).

The *Table* lists the electron and ion plasma frequencies for an atomic hydrogen plasma. An atomic hydrogen ion, having the least mass of all ions, has the highest f_{ip}/f_{ep}-ratio.

In the model of a plasma that we assume to determine the interaction of a plasma with a high-frequency electromagnetic field, therefore, only the

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electrons move and the ions are stationary. By accounting for all the forces that might conceivably act on the electrons (electric, magnetic, collision, pressure, etc.), you can solve for the electron motion. Once you know the electron motion, you can determine the electronic volume current density (J) in terms of the electromagnetic fields. $\underline{J}$ is then substituted in the Maxwell field equations, which for our problem may be written as:

$$(3) \qquad \nabla \times \underline{E} = -\mu_c \partial \underline{H}/\partial t, \quad \nabla \cdot \underline{E} = \tilde{\rho}/\epsilon_o,$$

$$(4) \qquad \nabla \times \underline{H} = \underline{J} + \epsilon_o \partial \underline{E}/\partial t, \quad \nabla \cdot \underline{H} = 0.$$

These equations can now be solved for the propagation of electromagnetic waves by standard methods (using the rationalized MKS system of units throughout).

It is the peculiar structure of the conduction current density that makes propagation through a plasma interesting. In many respects a plasma behaves as a lossy dielectric with a frequency-dependent dielectric constant. However, while an ordinary dielectric does not permit plane wave propagation with a longitudinal E-field, a plasma does permit such a wave, because there is a non-zero divergence of the electric field:

$$(5) \qquad \nabla \cdot E \neq 0.$$

"Electromechanical" space charge wave

Such a wave is called an "electromechanical" space charge wave. It causes a plasma to become anisotropic when an externally applied magnetic field exists in the plasma region.

The general force equation on the plasma electrons may be written as:

$$(6) \qquad \underline{v} \times \underline{\omega_c} + \nu_c \underline{v} + \underline{v} \cdot \nabla \underline{v} + \partial \underline{v}/\partial t = \eta[\underline{E} + \underline{vB} - (c_o/\omega_p)^2 \nabla(\nabla \cdot \underline{E})].$$

By solving this equation for $\underline{v}$ and substituting the result ($\underline{J} = \rho \underline{v}$) in *Equations 3 & 4*, special cases may be considered. In all the cases we will discuss, the non-linear terms in *Equation 6* are considered small and are neglected; the various cases for the propagation of waves through plasmas then depend on what further terms in *Equation 5* can be neglected:

• *Uniform-density plasma, no externally superimposed magnetic field, negligible losses* ($\omega_o = 0$, $\nu_c = 0$) —In this case, *Equation 6* can be solved for $\underline{v}$, so that $\underline{J}$ becomes:

$$(7) \qquad \underline{J} = -j(\epsilon_o \omega_p^2/\omega)[\underline{E} - (c_o/\omega_p)^2 \nabla(\nabla \cdot \underline{E})],$$

assuming that all time-varying quantities vary as $e^{j\omega t}$. The solution of Maxwell's equations now gives:

$$(8) \qquad \nabla \times (\nabla \times \underline{H}) - (\omega/c)^2[1 - (\omega_p/\omega)^2]\underline{H} = 0,$$

$$(9) \qquad \nabla^2(\nabla \cdot \underline{E}) + (\omega/c_o)^2[1 - (\omega_p/\omega)^2]\nabla \cdot \underline{E} = 0,$$

which may be solved for two types of waves. *Equation 8* is the ordinary equation for electromagnetic wave propagation in a dielectric medium whose relative dielectric constant is:

Electron and Ion Plasma Frequencies for Atomic Hydrogen

n (particle/cm²)	f_{ep} (mc)	f_{ip} (mc)
10^6	9	.21
10^8	90	2.1
10^{10}	900	21
10^{12}	9×10^3	210
10^{14}	90×10^3	2.1×10^3
10^{16}	900×10^3	21×10^3

Nomenclature

$\underline{B_o}$	externally superimposed magnetic field
c	speed of light in a vacuum
c_o	speed of sound in an electron gas, or $\sqrt{\gamma \eta T_e}$
f_{ep}	electron plasma frequency
f_{ip}	ion plasma frequency
J	electronic volume current density
[K]	tensorial relative dielectric permittivity
M	ion mass
m	electron mass
n	plasma electron density, or electrons per cubic centimeter
T_e	electron temperature, or $\sqrt{KT/Q}$ ev
v_g	group velocity
v_p	wave phase velocity
α	attenuation factor with units of reciprocal length
β	phase propagation characteristic, or $2\pi/\lambda$
Γ	complex propagation characteristic, or $\alpha + j\beta$
γ	ratio of specific heats for an electron gas
η	electron charge-mass ratio; equals Q/m, or 1.755×10^{11}
θ	angle between imposed magnetic field and direction of plan-wave propagation
λ	wavelength of electromagnetic waves
ν_c	collision frequency for momentum transfer, or the number of times per second that an electron is deflected 90 deg upon colliding with an atom; depends on the neutral gas and the electron energy
ρ	electron charge density, or $\rho_o + \tilde{\rho}$
χ	dielectric susceptibility of plasma
ω	externally superimposed radian drive frequency
$\underline{\omega_c}$	electron cyclotron frequency corresponding to an externally superimposed magnetic field; equals the negative product of η and $\underline{B_o}$, or 2.8 mc/gauss
ω_p	radian plasma frequency, or $2\pi f_{ep}$

10) $$K = 1 - (\omega_p/\omega)^2.$$

Equation 9 is the equation of propagation for compressional sound waves in a charged gas. Strangely enough, this wave may propagate *without generating a magnetic field.*

For plane-wave propagation in an infinite and uniform plasma a variation of the form $e^{j\omega t - \Gamma\xi}$ may be assumed for the field quantities. The propagation constants then are:

(11) $$E_z \neq 0, \quad \Gamma/j = \beta = \pm(\omega/c)\sqrt{K}$$

for a transverse electromagnetic wave,

(12) $$E_z \neq 0, \quad \Gamma/j = \beta_s = \pm(\omega/c_o)\sqrt{K}$$

for a longitudinal sound wave.

For the transverse wave, the impedance is:

(13) $$Z = E_x/H_y = \omega\mu_o/\beta = \frac{\sqrt{\mu_o/\epsilon_o}}{\sqrt{K}} = 377/\sqrt{K}\ \text{ohms}.$$

Figure 1 shows the phase characteristics of these two types of waves. This particular presentation is chosen because the wave phase velocity (v_p) is given by ω/β and the group velocity (v_g) by $\partial\omega/\partial\rho$. Waves of both types do not propagate if ω exceeds ω_p. Under these assumptions, therefore, a plasma is a high-pass filter.

Dispersion for plasma-filled waveguide

For a round waveguide filled with a uniform plasma of the type we have assumed, a solution of *Equations 8 & 9* subject to the boundary conditions gives these dispersion characteristics:

(14) $$\beta_{oj} = \frac{1}{c}\sqrt{\omega^2 - \omega_p^2 - \left(\frac{c\alpha_o{}^j}{R}\right)^2}, \quad J_o\alpha_o{}^j = 0$$

for a TM-wave,

(15) $$\beta_{1j} = \frac{1}{c}\sqrt{\omega^2 - \omega_p^2 - \left(\frac{c\gamma_1{}^j}{R}\right)^2}, \quad J_o\gamma_1{}^j = 0$$

for a TE-wave,

(16) $$\beta_{so} = \frac{1}{c_o}\sqrt{\omega^2 - \omega_p^2 - \left(\frac{c\alpha_o{}^j}{R}\right)^2}, \quad J_o\gamma_o{}^j = 0.$$

for a longitudinal sound wave.

Filling a waveguide with a plasma thus raises the cutoff frequency. The sound waves are hard to observe because they aren't associated with a magnetic field (and because to the first order they do not couple to the electromagnetic waves.) Also the finite temperature of the electrons does not appreciably affect the TEM-wave propagation.

• *Uniform-density plasma, no externally superimposed magnetic field, zero electron temperature, losses not negligible* ($\omega_c = 0$, $c_o = 0$)—In this case *Equation 6 reduces to:*

(17) $$\nu_c v + \partial v/\partial t = E.$$

and we get:

(18) $$J = \rho_o v = \sigma_r E + j\sigma_j E, \quad \sigma_r = -\epsilon_o\nu_c\chi, \quad \sigma_i = \epsilon_o\omega\chi,$$
$$\chi = (\omega_p/\omega)^2/[1 + (\nu_c/\omega)^2], \quad \epsilon = \epsilon_o(1 + \chi),$$

where χ is the dielectric susceptibility of the plasma. Substitution in the Maxwell equations gives:

(19) $$\nabla \times E = -j\omega\mu_o H, \quad \nabla \times H = \sigma_r E + j\omega\epsilon E.$$

For the infinite-medium TEM-plane wave solution of *Equation 19,* the propagation constant takes the complex form of:

(20) $$\Gamma = \alpha + j\beta, \quad \alpha = \frac{\omega}{c}\sqrt{\frac{-\epsilon + \sqrt{\epsilon^2 + (\sigma_r/\omega)^2}}{2\epsilon_o}},$$

$$\beta = \frac{\omega}{c}\sqrt{\frac{\epsilon + \sqrt{\epsilon^2 + (\sigma_r/\omega)^2}}{2\epsilon_o}}.$$

The wave amplitudes are damped as $e^{-\alpha z}$ in propagation through a plasma on which the electrons collide with neutral atoms. The resulting losses also remove the plasma frequency cutoff characteristic, and the plasma now transmits at all frequencies. *Figure 2* shows the attenuation and phase characteristics for TEM-waves in a lossy plasma.

In this case, the wave impedance is complex. It is given by:

(21) $$Z = \frac{E_x}{H_y} = \frac{\sqrt{(\mu_o/\epsilon_o)}\,e^{j\tan^{-1}(\alpha/\beta)}}{[(1 + \psi)^2 + (\nu_c/\omega)^2\psi^2]^{1/4}}.$$

Except for the particular dependence of conductivity

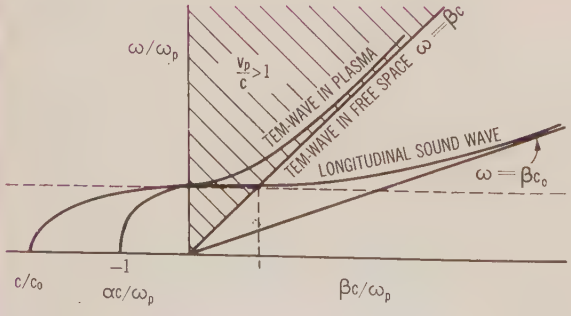

FIGURE 1: Phase characteristics of plane plasma waves ($\omega_c = 0$, $\gamma_c = 0$, $T_e \neq 0$).

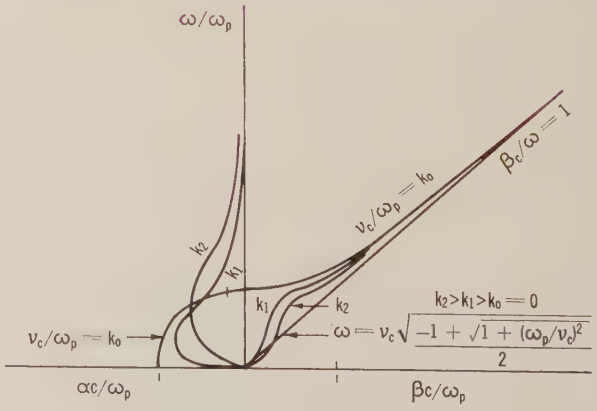

FIGURE 2: Phase characteristics of a lossy plasma for plane TEM-waves.

Plasma Electronics

Considering that probably over 99 per cent of the universe is plasma, it's startling how much less we know about the fourth state of matter than about the solid, gaseous, and liquid states. Though even its name is not firmly established, plasma electronics is not entirely new. Scientists have long been aware of the tenuous atmospheres of free electrons and ions existing in space, and plasmas have been put to use in practical devices like fluorescent lamps and electron tubes. But it remained for fission and fusion research to set off plasma electronics as a highly important area of scientific study.

Plasma electronics is extremely complex, and its problems are many, while satisfactory solutions are few. It involves a large number of disciplines, including aerodynamics, electromagnetic waves, quantum electronics, physical electronics, magnetohydrodynamics, thermodynamics, and particle and radiation physics.

Even on the basis of the little we know, it appears that plasmas can be used in a number of practical electronic devices. As plasmas both create and inter-react with both electric and magnetic fields, they conceivably might replace electronic devices using wires, capacitors, and other conventional circuit elements or improve their operation.

Particularly in microwave design, plasmas look promising as oscillators, amplifiers, waveguides, filters, switches, attenuators, and antennas. Because electromagnetic waves can propagate through a plasma in the presence of a DC magnetic field, it has been suggested that plasmas replace the slow-wave structure in TWTs. The electron beam could then be modulated by varying the plasma properties. In experiments along these lines, a growth of the modulation has been observed—apparently there is a possibility of microwave amplification by this technique.

Beam plasma systems have been proposed for the generation of millimeter-wave signals. In lab experiments, microwave energy has been generated with plasma beams.

Researchers are working on plasma waveguides whose mode and bandpass properties can be controlled by external magnetic fields. At low gas pressures, the conductivity and diffusion of the charged particles in a magnetic field can be used for phase shifting, switching, harmonic generation, and non-reciprocal transmission of microwave energy. In high-density plasma systems, microwave absorption is high. Because of the large number of collisions between electrons and neutral molecules, dense plasmas can be used as microwave-kinetic energy converters, for which there are many potential applications (heat exchangers, microwave powered gas jets, etc.).

The Faraday effect, polarization properties, double refraction, and non-linearities are among the other potentially useful characteristics of plasmas, all of which could be quite important in microwave circuits.

No plasma device is ready yet for use in practical systems or even in experimental ones, and none will be for perhaps the next 5-10 years.

and dielectric constant on frequency, these results are typical for plane-wave propagation through a lossy dielectric. (The longitudinal electromechanical wave is not discussed since it does not affect the TEM-wave.)

For a plasma-filled waveguide, *Equation 19* can be solved with no particular difficulty.

The medium becomes anisotropic

• *Uniform-density plasma, uniform externally applied magnetic field, negligible electron temperature and losses* ($\vec{B}_o = i_3 B_z$, $c_o = 0$, $\nu_c = 0$)—In this case, *Equation 6* reduces to:

$$\omega_c \underline{v} i_3 + \partial \underline{v}/\partial t = \eta \underline{E}. \tag{22}$$

The externally applied magnetic field makes the medium anisotropic as seen from *Equation 22*, and we get:

$$\underline{J} = (\underline{i}_1, \underline{i}_2, \underline{i}_3) \begin{bmatrix} \sigma_{11} & j\sigma_{12} & 0 \\ -j\sigma_{12} & \sigma_{11} & 0 \\ 0 & 0 & \sigma_{33} \end{bmatrix} \begin{bmatrix} E_x \\ E_y \\ E_z \end{bmatrix}. \tag{23}$$

With this expression, we can reduce *Equation 3* to:

$$\nabla \times \underline{E} = -j\omega\mu_o \underline{H}, \quad \nabla \times \underline{H} = j\omega\epsilon_o [K] \cdot \underline{E}, \tag{24}$$

where $[K]$ is the tensorial relative dielectric permittivity:

$$[\underline{K}] = (\underline{i}_1, \underline{i}_2, \underline{i}_3) \begin{bmatrix} K_{11} & jK_{12} & 0 \\ -jK_{12} & K_{11} & 0 \\ 0 & 0 & K_{33} \end{bmatrix} \begin{bmatrix} \underline{i}_1 \\ \underline{i}_2 \\ \underline{i}_3 \end{bmatrix}. \tag{25}$$

$$K_{11} = 1 - (\omega_p/\omega)^2/[1 - (\omega_c/\omega)^2],$$
$$K_{12} = (\omega_c/\omega)(\omega_p/\omega)^2/[1 - (\omega_c/\omega)^2], \quad K_{33} = 1 - (\omega_p/\omega)^2.$$

Again *Equations 3 & 4* can be solved for plane-wave propagation in any infinite medium, with the resulting propagation constant given by:

$$(\beta^{\pm} c/\omega)^2 = (K_{33} - AN^{\pm})/(1 + A\cos^2\theta), \tag{26}$$
$$A = (\omega_c/\omega)(K_{12}/K_{11}),$$
$$N^{\pm} = \tfrac{1}{2}[\sin^2\theta \pm \sqrt{\sin^4\theta + K_{33}^2(\omega/\omega_c)^2\cos^2\theta}],$$

where θ is the angle between the imposed magnetic field and the direction of plane-wave propagation.

Four wave combinations are possible

In this case, the propagation characteristics are quite complicated. For θ equaling zero and propagation along the magnetic field, there are four possibilities: two right-hand circularly polarized TEM-waves, a left-hand polarized TEM-wave and a linearly polarized electromechanical body wave. For θ equaling 90 deg, two elliptically polarized TEM-waves and a linearly polarized TEM-wave are possible. For intermediate angles, mixtures of these waves are possible (*Fig. 3*).

For a waveguide filled with a plasma in a uniform axial magnetic field, solutions are possible but quite difficult. One of the most important results is that derived plane-wave modes with infinite β for finite α (resonance) now become backward-wave modes. This

type of wave can only exist because of the existence of the electromechanical mode of our first case. The presence of an externally superimposed magnetic field couples this mode to the electromagnetic modes. TE- or TM-modes of propagation by themselves are not possible in such a plasma-filled waveguide.

• *Uniform-density plasma, zero temperature, no externally superimposed magnetic field, negligible losses, electronic component of plasma moving with uniform drift velocity (U_o)*—In this case, the phase characteristics of the electromechanical space charge waves are appreciably affected by the uniform drift velocity of the plasma electrons. For the propagation of plane waves in a direction parallel to the direction flow, the longitudinal and transverse current densities become, respectively:

$$J_z = -j\omega\epsilon_o(\omega_B/\omega)^2\underline{E}_z/(1-\beta U_o/\omega)^2, \tag{27}$$
$$J_t = -j\omega\epsilon_o(\omega_B/\omega)^2\underline{E}_t/(1-\beta U_o/\omega).$$

The effective dielectric constant for the medium TEM-waves along the direction of the drift velocity is:

$$\epsilon = \epsilon_o[1-(\omega_B/\omega)^2/(1-\beta U_o/\omega)]. \tag{28}$$

The solution of the Maxwell wave equations with these current densities gives the longitudinal electromechanical and transverse electromagnetic wave phase characteristics as, respectively:

$$\beta\mu_o/\omega = 1 \pm \omega_B/\omega, \tag{29}$$
$$(\omega/\omega_B)^2 - (\beta c/\omega_B)^2 = 1/(1-\beta U_o/\omega).$$

The phase characteristics of the electromechanical wave are interesting. If the electron temperature in our

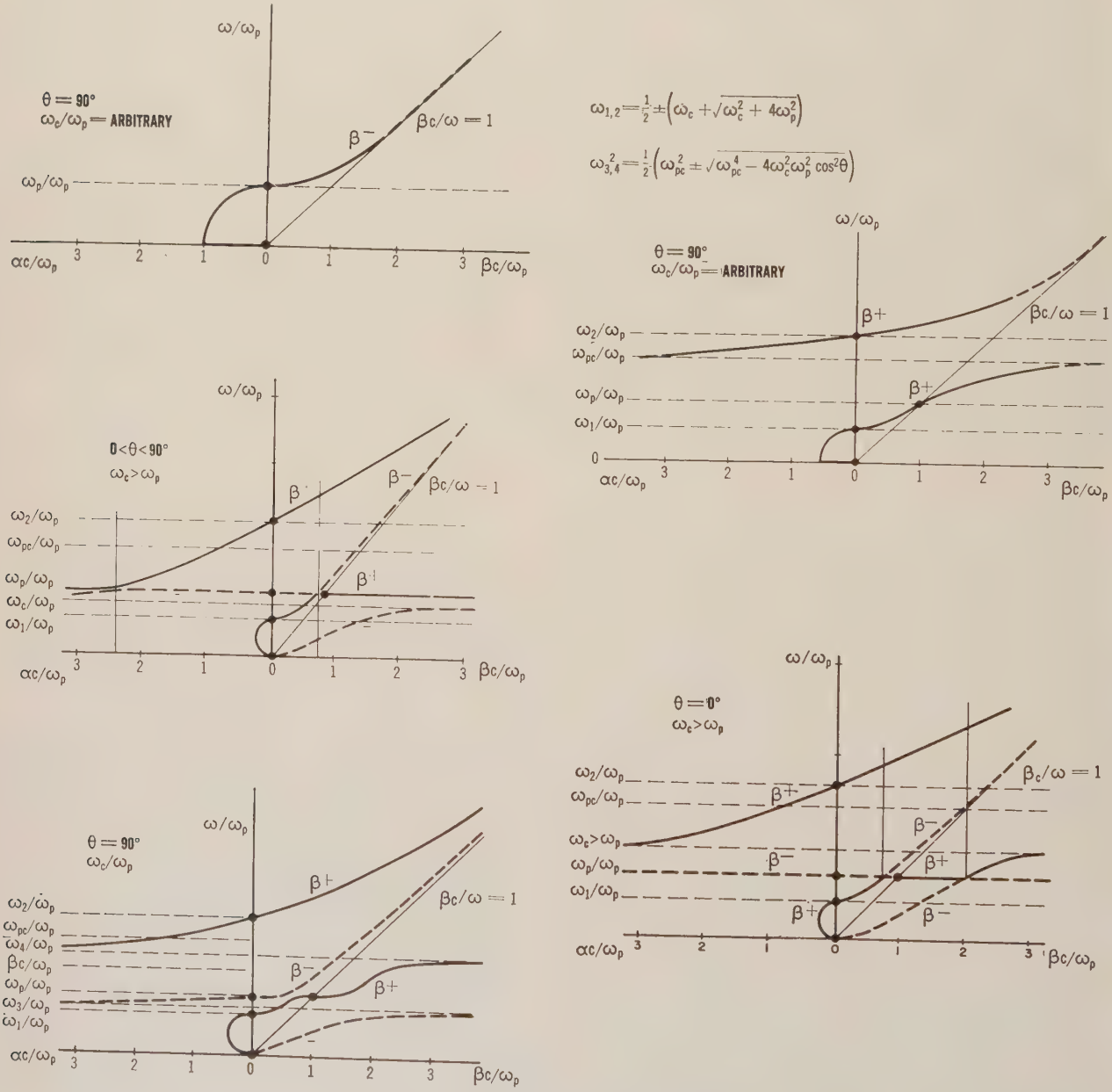

FIGURE 3: Phase characteristics of anisotropic plasmas.

first case had been zero, that particular phase characteristic would have degenerated to a straight line for $\omega = \omega_p$. In other words, any phase velocity would have been possible at the plasma frequency for zero group velocity. In the new situation, this degenerate phase characteristic has acquired a slope such that the group velocity equals the drift velocity of the electrons. In addition, another branch of the electromechanical wave has appeared (*Fig. 4*). The phase characteristic of the TEM-wave is slightly modified from that of our first case.

The two electromechanical waves are merely the fast and slow space charge waves of klystron theory. If the moving electrons are given a velocity modulation U_{10} at $z = t = 0$, the two waves are both excited and can be combined to give a wave varying as:

(30) $$U_1 = U_{10} \cos(\omega_B z/U_o) e^{j\omega(t - z/U_o)}.$$

In other words, the amplitude of a traveling-wave velocity modulation is space modulated. Such a wave does not, however, carry electromagnetic power. The velocity modulation creates a current modulation that is 90 deg out of space phase with it. It is the interaction of this current modulation with an output coupling mechanism that generates electromagnetic power.

A velocity modulation is produced

If a background plasma of frequency ω_p is added to this situation, the result is a velocity modulation of the form:

(31) $$U_1 = U_{10} \cos\{\omega_B z/[U_o\sqrt{-(\omega_p/\omega)^2 + 1}]\} e^{j\omega(t - z/U_o)}.$$

If ω_p exceeds ω, this equation obviously becomes:

(32) $$U_1 = U_{10} \cosh\{\omega_B z/[U_o\sqrt{(\omega_p/\omega)^2 - 1}]\} e^{j\omega(t - z/U_o)}.$$

The amplitude of the velocity modulation grows essentially exponentially with distance. The stationary plasma has acted as a *circuit* for interaction with the moving plasma. This effect can be used for the amplification of high-frequency power in the manner of a traveling-wave tube.

As we have pointed out, in the cases of propagation of electromagnetic waves through plasmas that we have discussed, the plasma may be treated as a dielectric with a frequency-dependent dielectric constant, or as a dielectric circuit element. This dielectric, however, has the interesting peculiarity that, even under the simplest assumed conditions, it permits the existence of an electromechanical wave. For a zero-temperature electron gas, this wave does not propagate; for a finite-temperature electron gas, it propagates as a modified sound wave. When an externally superimposed magnetic field is added, this wave couples to the electromagnetic waves and causes resonances at certain frequencies. When the plasma electrons are given a drift velocity, it is this electromechanical wave that allows the amplification of electromagnetic power.

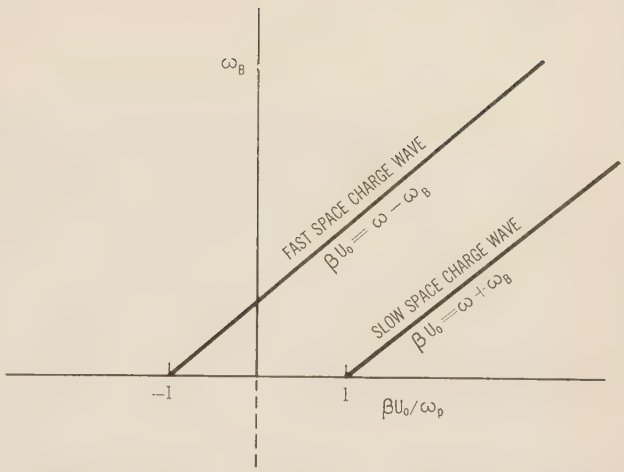

FIGURE 4: Phase characteristics of the electromechanical waves of a moving plasma.

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MULTIVIBRATORS built with thin films

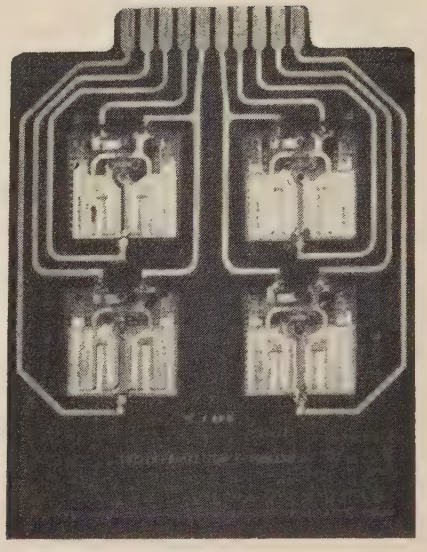


FIGURE 1: Four thin-film multivibrators flush-mounted on phenolic plug-in card providing mechanical support and electrical connections.

One of the most promising microminiaturization techniques is the vacuum-deposition of functional circuits by electron bombardment. As functional circuits shrink in size, though, the problems of mounting, support, and connections become steadily more troublesome.

Servomechanisms went far toward overcoming these problems when it produced a series of free-running thin-film multivibrators with basic frequencies of 1800, 3600, 5400, 7200, 9000, and 10,800 cps. The basic substrate for these circuits is a one-inch square of soft glass designed to accommodate resistors and conductors on one side and capacitors and transistors on the other. Fired silver tabs provide the connections to external circuits. The conductor patterns are deposited aluminum films: capacitors are formed of aluminum for the upper and lower plates and silicon monoxide as the dielectric. The finished glass plates are mounted flush with the surface of phenolic printed-circuit cards in which holes have been routed out. Several modules can be mounted on a single card, and each module can be replaced without disturbing the others.

THE BASIC FUNCTION of Servomechanisms' free-running multivibrators using vacuum-deposited, thin-film passive components and uncased transistors is to supply a synchronizing trigger pulse to a blocking oscillator. These units were designed for Boeing to supply specific repetition rates of 1800-10,800 cps with a tolerance of ±2 per cent at an upper limit of 50 deg C. For feasibility studies, each multivibrator module was built on a one-inch square soft-glass substrate, but the same technique can be applied to much smaller production microcircuits.

A set of four of the one-inch prototypes is mounted on a phenolic, printed-wiring, plug-in-card (*Fig. 1*). Each module is embedded in the surface of the card, providing adequate mechanical support without stressing the glass. The chief advantage of this form of packaging is that a module doesn't force you to remove a whole card—each module can be replaced separately. Connections to the modules are flush with the printed wiring of the card.

One of our plug-in cards has four one-inch modules with output frequencies of 1800, 3600, 5400, and 7200 cps; another has four modules with outputs of 5400, 7200, 9000, and 10,800 cps. The same circuit is used

* Servomechanisms, Inc., Research Div., Goleta, Calif.

by H. J. Weber,
Chief Development Engineer, Research Div., Servomechanisms, Inc.*

for both modules and only the capacitor and timing resistor values are different (*Fig. 2*).

The limiting values of capacitance and resistance depend on the disposition technique and material and, of course, on the allowable area of the module wafer. An upper limit of 100,000 ohms was set for resistors, but the actual values range from 40,000 to 80,000 ohms. The capacitors vary from 0.0017 to 0.005 uf.

We chose a collector-to-base-coupled type multivibrator circuit for microminiaturization on the basis of optimum RC values, transistor characteristics, minimum number of components, good frequency stability, and negligible jitter. The collector voltage (V_{cc}) of 4.5 V was determined by the maximum permissible reverse voltage from emitter to base (V_{EBO}). The base resistor is returned to the supply voltage (*Fig. 2*). This results in a more linear base waveform, and the steeper slope applied to turn the base on makes the period less sensitive to voltage variations. The low rates of the multivibrators require large RC time constants (see *Box*).

Both sides of the glass substrate are used for component deposition. The first step in fabrication is to drill the small holes through the glass blank through which both sides will be connected. For the subsequent steps, masks are required to lay down the various

RC Time Constant Derivations

The maximum allowable value of time-constant resistors R_{b1} and R_{b2} is limited by deposition techniques to less than 100,000 ohms. To show how Servomechanisms derived the time constants for its thin-film multivibrators, we will assume a base frequency of 3440 cps. The period is made asymmetrical by trimming the timing resistors.

The full multivibrator period is:

(1) $$T = T_1 + T_2,$$

where T is 290 usec; T_1, 160 usec; and T_2, 130 usec. The equation for T_1 is:

(2) $$T_1 = \tau_2 \ln \left(\frac{V_{cc} - V_1}{V_{cc} - V_2}\right),$$

where τ_2 equals $R_{b1} C_2$. The equation for T_2 is:

(3) $$T_2 = \tau_3 \ln \left(\frac{V_{cc} - V_1}{V_{cc} - V_2}\right),$$

where τ_3 equals $R_{b2} C_1$. In both equations, V_{cc} is the collector voltage and equals 4.4 V, V_1 is the maximum negative swing and equals −3 V, and V_2 is the maximum positive swing of the base waveform about the zero axis and equals 0.6 V. These equations give the total period of the multivibrators as:

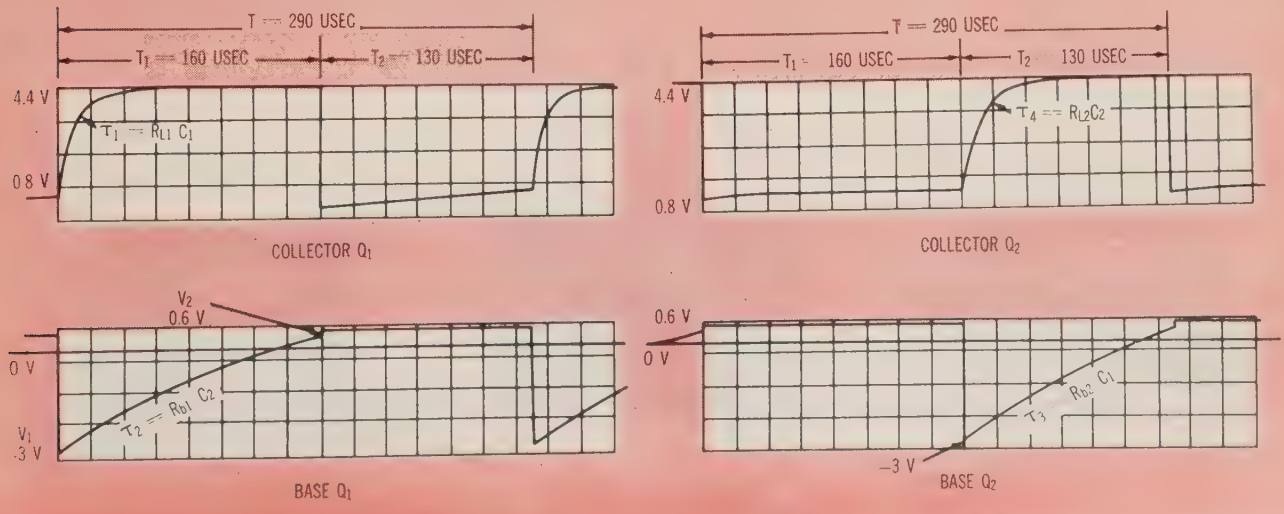
(4) $$T = (\tau_2 + \tau_3) \ln \left(\frac{V_{cc} - V_1}{V_{cc} - V_2}\right).$$

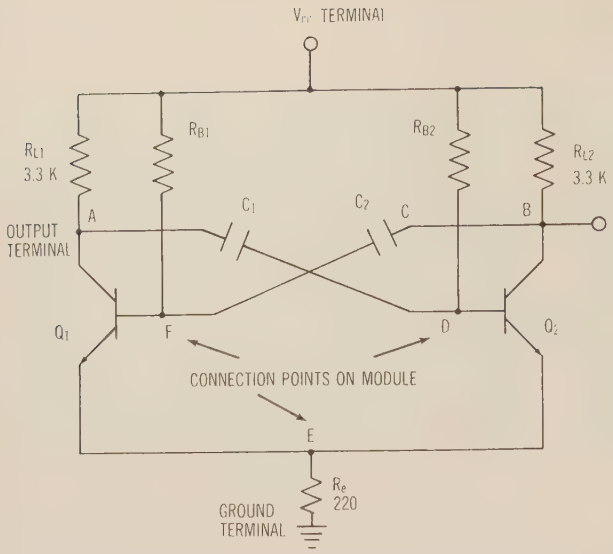
Because the common emitter resistance (R_e) is much smaller than R_L or R_b, it is omitted in the calculations. From Equations 2, 3 & 4 we therefore get, respectively:

$$T_1 = 2.3 \times 10^{-4} \ln 1.95 = 154 \text{ usec},$$
$$T_2 = 2.0 \times 10^{-4} \ln 1.95 = 134 \text{ usec},$$
$$T = 4.3 \times 10^{-4} \ln 1.95 = 288 \text{ usec}.$$

These values, which apply to the rise time of the base waveforms, come close to the measured values shown in the Waveform Diagram.

The rise time of the collector waveform (τ_1 and τ_4) equals $2.2(R_{L1}C_1)$ for Q1 and $2.2(R_{L2}C_2)$ for Q2. Its value therefore is $2.2(16.5 \times 10^{-6})$, or 36.3, usec, which agrees well with the performance shown in the Diagram.





Nominal Capacitor and Resistor Values

Frequency (cps)	C_1, C_2 (uf)	R_{b1}, R_{b2} (K)
1800	0.005	80
3600	0.005	40
5400	0.0033	40
7200	0.0025	40
9000	0.0020	40
10,800	0.0017	40

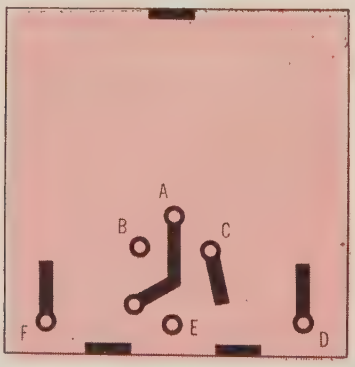
FIGURE 2: Connection points (letters) of thin-film multivibrators and typical values of resistors and capacitors for a range of frequencies.

patterns of conductive, capacitor-dielectric, and resistance material (*Fig. 3*).

Silver paint is applied by process screens and is later fired to provide external solder connection points and to fill the holes in the substrate, connecting both sides. The connections are lettered to correspond to the letters in the circuit schematic.

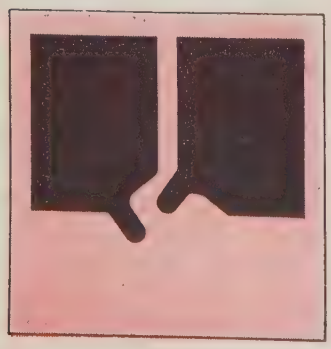
The master artwork for the process screens and also for the subsequent evaporation masks is made to a 10-times scale and is then reduced to insure dimensional accuracy. The evaporation masks are etched from stainless steel shim stock.

The capacitors are fabricated by evaporation—through successive masks—of two conducting plates of aluminum separated by an evaporated layer of silicon monoxide dielectric. Material deposition for both capacitor and resistor sides of the module is done in a vacuum chamber that has a "lazy-susan" arrange-

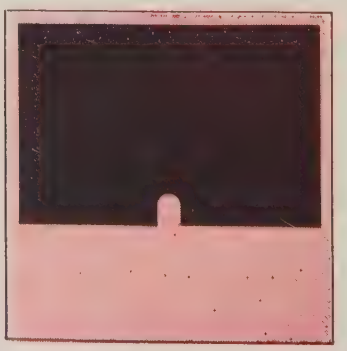


SCREENED SILVER PATTERN

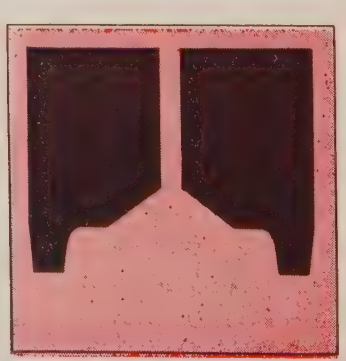
FIGURE 3: Process screen and evaporation masks for the capacitor and resistor sides of a module. The screen deposits silver paint under normal room conditions, while the capacitor elements are thin-film deposits made through masks in a vacuum. These elements are etched from stainless steel. On the capacitor side, deposition begins with the bottom plate and ends with the top plate. On the resistor side, the conductive elements are first.



BOTTOM CAPACITOR PLATE



DIELECTRIC



TOP CAPACITOR PLATE

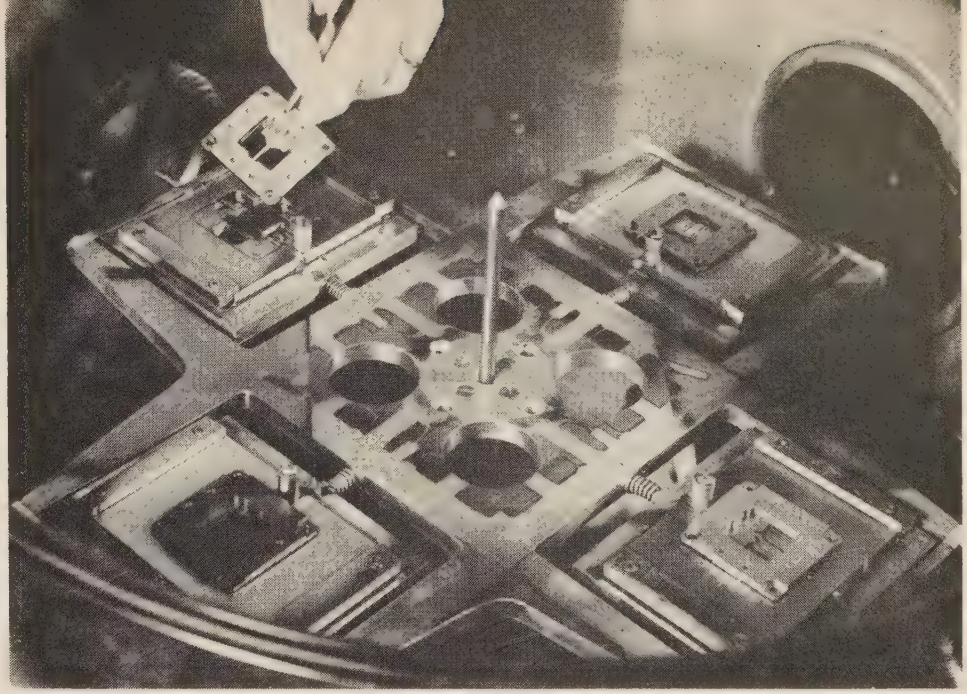


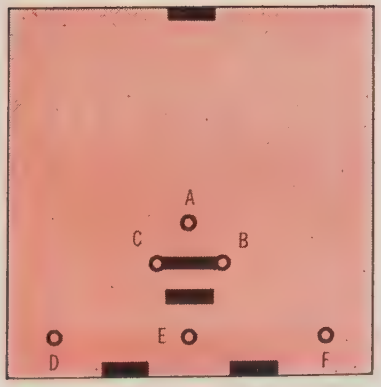
FIGURE 4: On lazy-susan arrangement inside a vacuum chamber, thin films are deposited on four substrates during a single pump-down. Observation ports are at left and top right. The operator holds a stainless steel mask through which capacitor plates are deposited.

ment for handling four substrates during a single pump-down (*Fig. 4*).

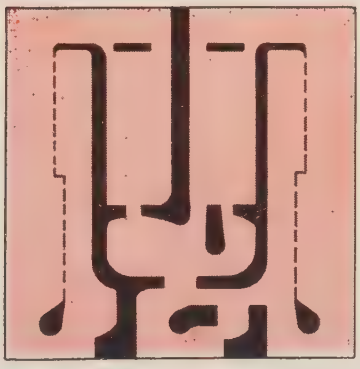
The resistor side of the module is evaporated in two steps. In the first, the conductive elements and connectors, which usually are aluminum, are deposited; in the second, the resistance elements, which are of nickel-chromium alloy and are deposited to predetermined values. These are controlled by monitoring the value of a sampling resistor.

The resistor patterns for R_{b1} and R_{b2} can be tailored to final values after deposition and aging—if the deposited value is too low the final value can be trimmed by scribing conducting shorting bars. The pattern in *Figure 3* can be increased 30 per cent in resistance to a tolerance of one per cent of the desired value.

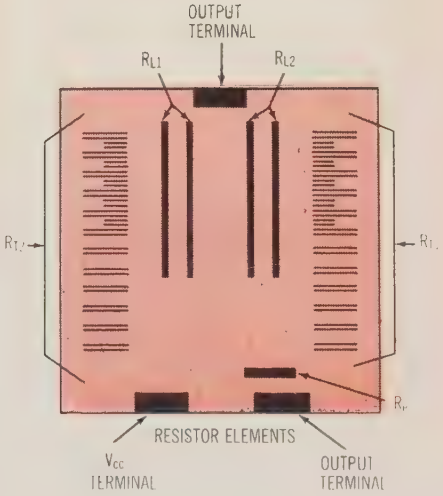
Scribing one of the shorting bars in the upper section of R_{b1} or R_{b2} provides coarse resistance trim, while



SCREENED SILVER PATTERN



CONDUCTIVE ELEMENTS



scratching out one of the lower bars gives fine trim (*Fig. 5*). The module can be adjusted to within one per cent of the desired frequency.

When the vacuum deposition is concluded, the resistance is measured and the module is heat-soaked. At room temperature, the resistance generally increases 2-4 per cent after the baking. Repeating the treatment several times stabilizes the resistances within one per cent.

Variations are compensated for

For the capacitors, leakage currents of less than 0.1 μamp and minimum breakdown voltages of 25 V are acceptable. Slight variations in capacitance are compensated for by the resistance trim operation.

The transistors are uncased silicon chips of microminiature Fairchild 2N697 mesas. They are attached to the module with a small iron with a special three-mil tip. A low melting-point solder is also required.

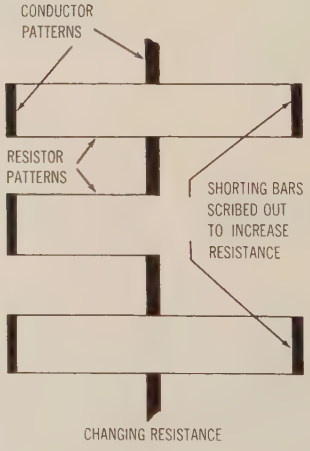
In lab tests of 16 modules on four plug-in-cards, all modules except the 3500-cps one remained well within the ±2 per cent tolerance for frequency drift in the course of a typical operating day of eight hours. For a two per cent change in the 4.5 V collector supply, the greatest frequency shift was only 0.68 per cent; ½ of the 16 modules, however, remained within ±0.08 per cent. The waveforms for the various units closely approximated those shown in the *Box*.

Smaller modules can be used

When the capacitors and resistors can be held to low values, as in circuits operating in the megacycle region, substantially smaller modules can be used. For instance, we have produced a bistable multivibrator, or flip-flop, on one side of a 0.35-in.-square glass substrate that contains five capacitors, 10 resistors, four diodes, and two transistors—a total of 21 components.

At reduced sizes, a single mask can be used to deposit 16 circuits in each station of the lazy susan, or a total of 64 circuits at one pump-down. A lazy susan with 16 stations for the simultaneous depositing of 256 circuits is under development.

More reliable interconnections can be produced if thermocompression bonding is used instead of soldering, and we have therefore developed a suitable bonding machine. Its tip is raised and lowered by means of a foot switch. This actuates a series of microswitches that apply the proper temperature and pressure for the required period.



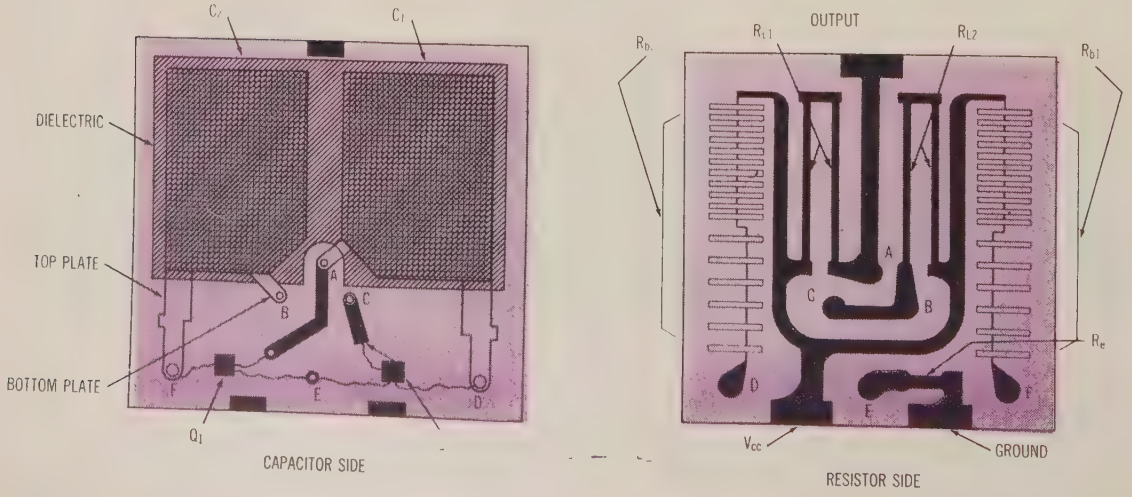


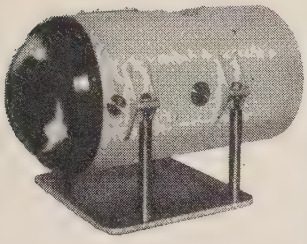
FIGURE 5: Capacitor and resistor sides of a finished module (below). For the capacitor side, vertical cross-hatching shows the top plate: horizontal cross-hatching the bottom plate: and slanted cross-hatching the dielectric. The circled letters are not part of the process—they show the connections, which are lettered just as on the schematic (Fig. 2). Right: Method of laying conductor and resistor patterns to provide a means of changing the resistance.

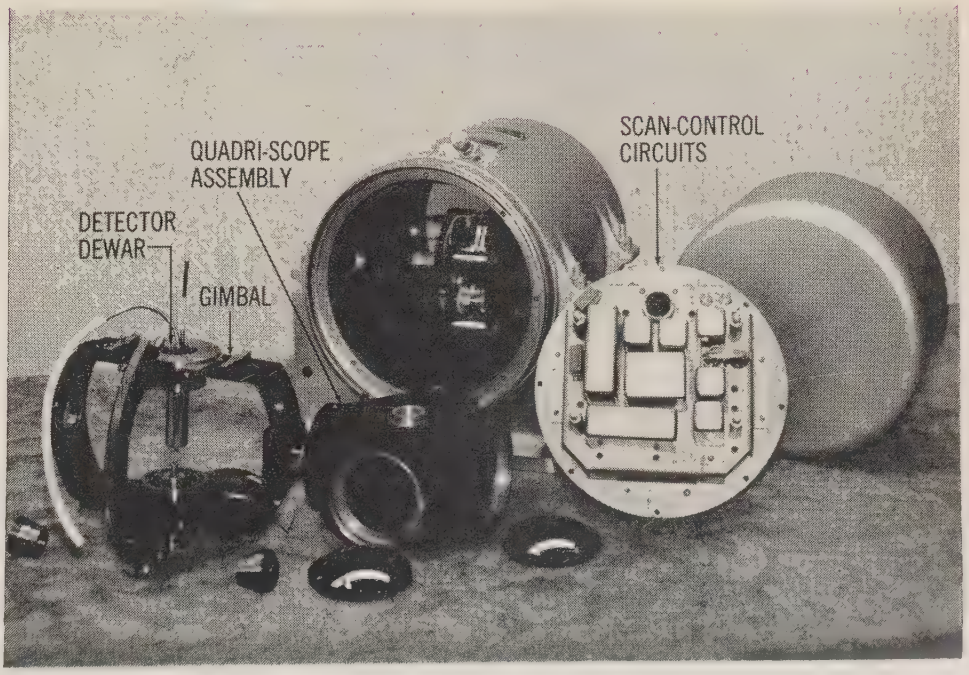
Track-while-scan IR system

for automatic threat evaluation

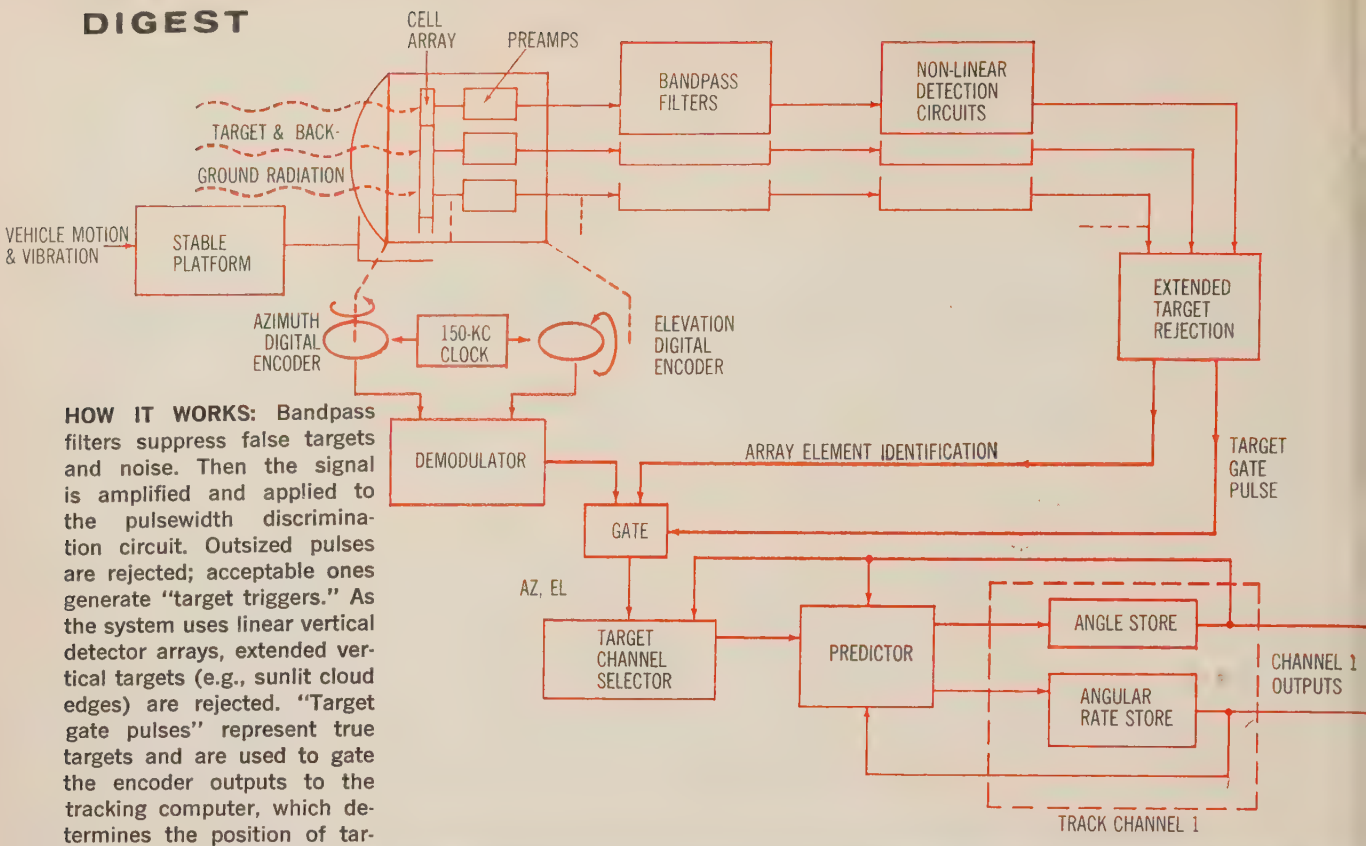
by **Bernard Kovit,** Associate Electronics Editor

A SERIES of advanced passive IR scanning and tracking systems for the 3.5-5.5-micron region is being produced by Electronics & Ordnance Div., Avco Corp., Cincinnati, Ohio, as an outgrowth of Avco's Avscan design. The basic Avscan is a continuous-scan search system with a rotating and nodding gimbaled package of four IR achromats that sequentially focus incident radiation on a liquid-N_2-cooled indium antimonide (InSb) photovoltaic detector. A power supply, a liquid-N_2 supply, and a three- or five-inch display unit complete the system. A more ambitious track-while-scan design replaces the display with a digital computer subsystem. While the quadri-scope constantly scans a fixed 90-deg-azimuth, 40-deg-elevation sector at three frames per second, single or multiple targets are stored on a frame-to-frame basis and are tracked by digitally processing the az-el scan readout. This sampled-data computer takes frequent periodic "looks" at each target and computes the angular target position between looks. To get high resolution and minimum background noise, Avco uses extremely small fields of view (each element has a 4.3×0.5-millirad instantaneous FOV). A split 20-element detector array provides scan overlap for getting a uniform azimuth scan and a line raster with no dead time. The system can be used for surveillance, threat evaluation, and weapons control on high-performance aircraft. For satellites, a greatly modified version (which may use the satellite's rotation instead of its own) is being worked on. Write in No. 60 on Reader Service Card for more information.

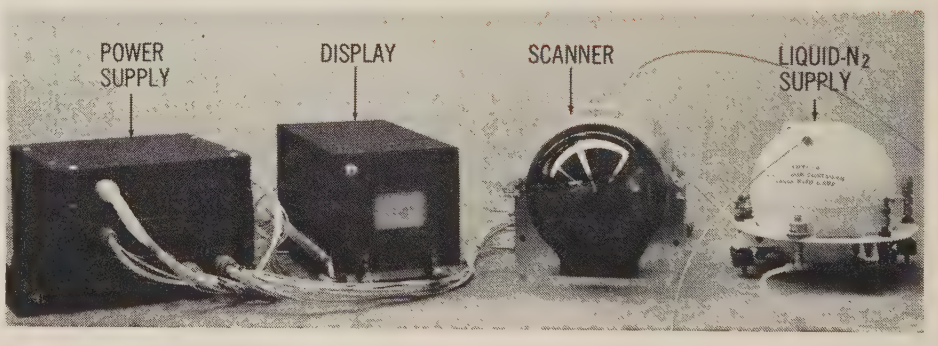


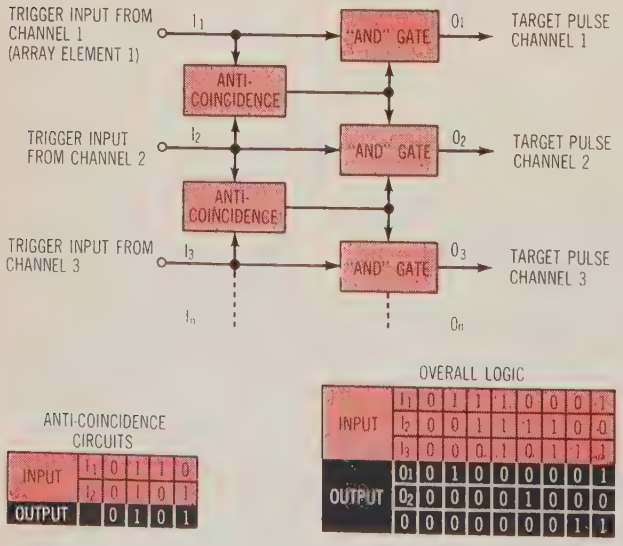


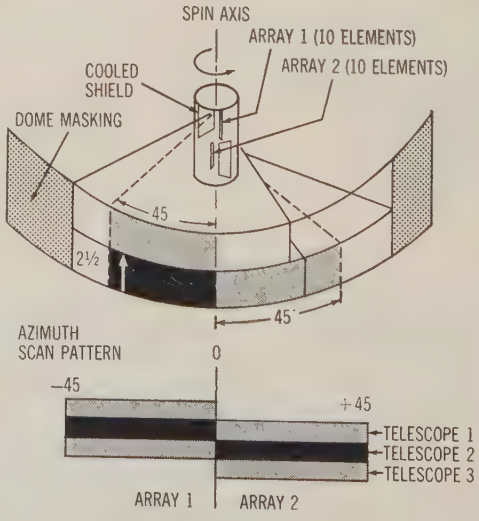
DISASSEMBLED IR scanner head shows tight packaging design. The unit weighs about 20 lb. The detector dewar goes into a larger cylinder that is evacuated to keep the IR window from frosting up.



HOW IT WORKS: Bandpass filters suppress false targets and noise. Then the signal is amplified and applied to the pulsewidth discrimination circuit. Outsized pulses are rejected; acceptable ones generate "target triggers." As the system uses linear vertical detector arrays, extended vertical targets (e.g., sunlit cloud edges) are rejected. "Target gate pulses" represent true targets and are used to gate the encoder outputs to the tracking computer, which determines the position of targets in the search field and gates target position from frame to frame to eliminate false targets. When the target has moved after being seen in the previous frame, the next time the target selector gates open, the new target-position information comes into the az-el storage registers. The photo shows the complete Avscan search system.

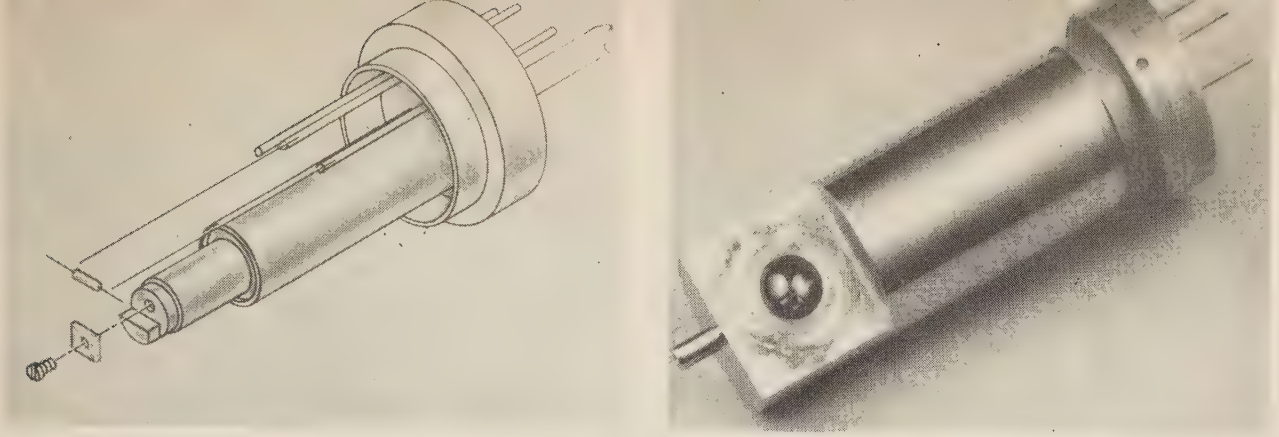






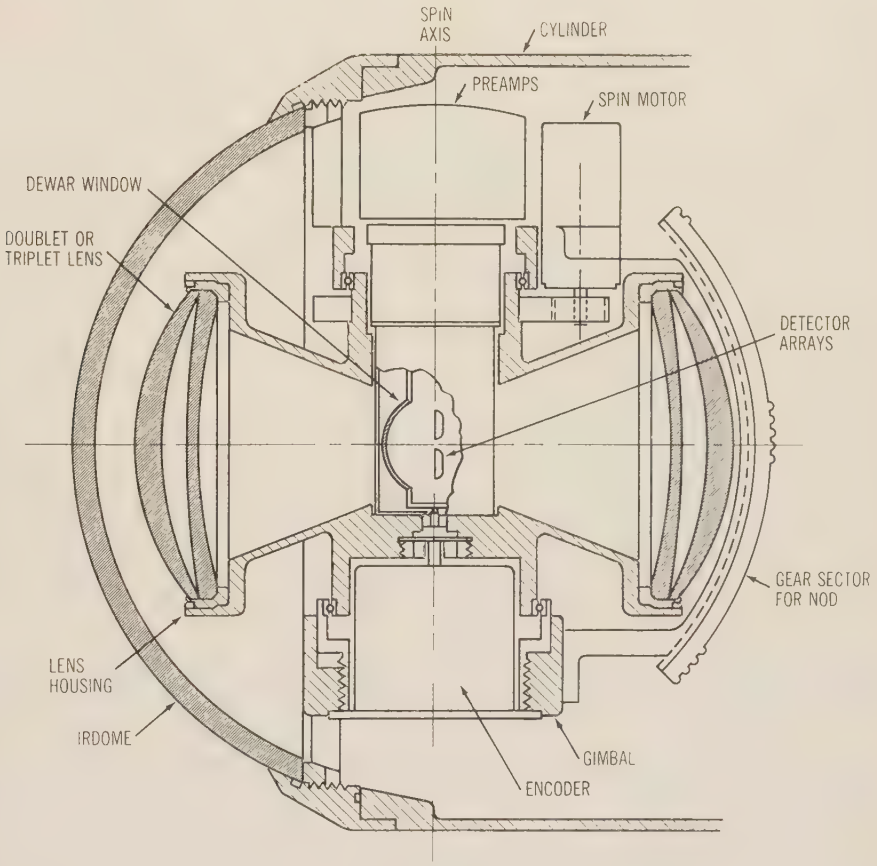
DISCRIMINATION LOGIC eliminates false targets produced by sources like sunlit cloud profiles sensed simultaneously by several adjacent array elements. Right: Split-array design insures that an array is operating while any telescope is moving out of or into position.

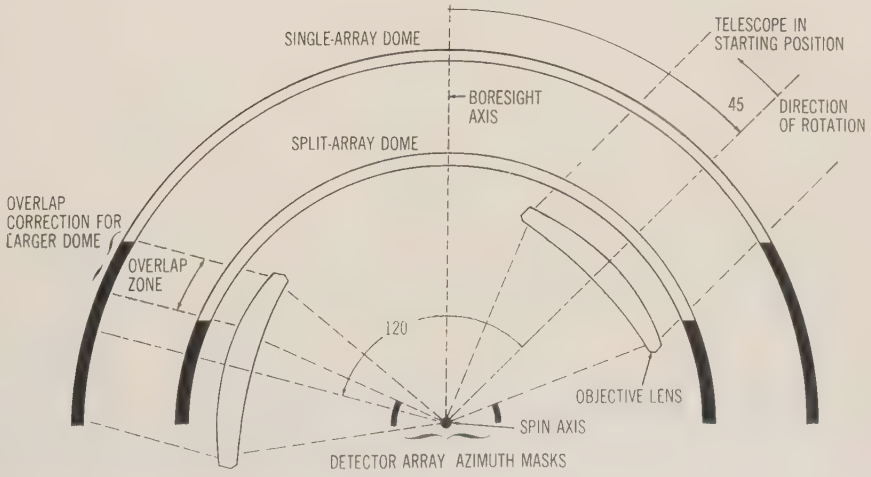
The 40-deg elevation coverage is obtained by sixteen 2.5-deg vertical strips. A contiguous line raster pattern is achieved by electronically switching an array out of the readout sequence in time with the departure of one scope and the arrival of the next.

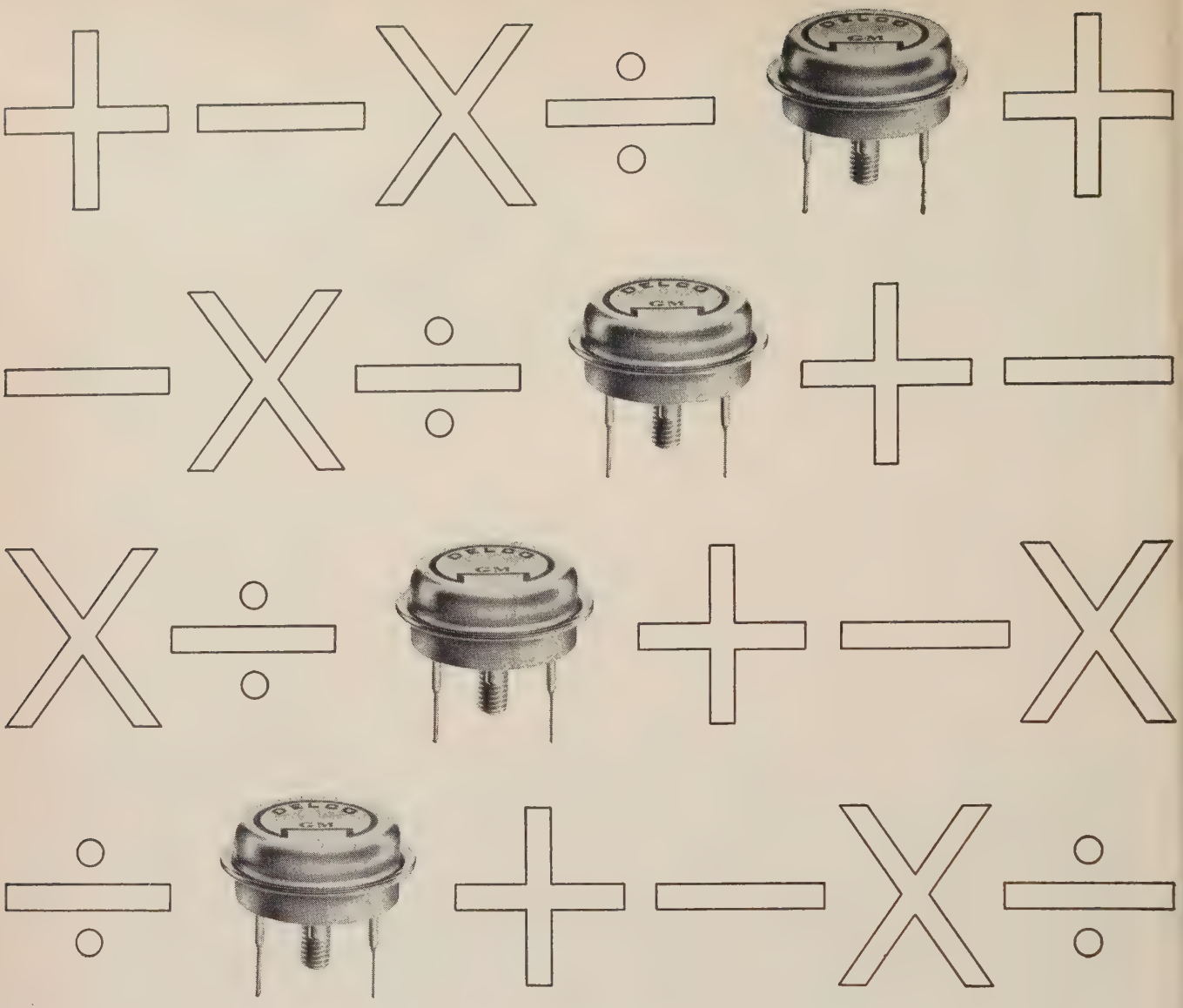


DEVELOPMENTAL side-looking dewar (right) and internal design of the split-array holder (above). Grown PN junction detectors are used. Ten-element "comb" arrays are made in an etched 0.030-in.-thick InSb slab by cutting slots through them at a 30-deg angle to the PN junction, giving uniform sensitivity and linear alignment.

SCAN HEAD: Acute packaging problems made Avco go to a refractive rather than a reflective system. Dome diameter is 10 in; collecting diameter, 4.625 in.; f number, 1; normalized detectivity, [D* (500 deg F, 10 kc, 1)], 1.5 × 10^{10} cm-cps$^{1/2}$/W. Bottom: Plan-view of a three-scope drum scanner coverage. Larger dome would be required to get total field of view and sequential scanning with a single array. Split arrays let you use smaller dome for full coverage. Masks cut out unwanted side radiation.







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No. 89 on Reader Service Card

IR instrumentation

a sure bet for spacecraft

by Eric M. Wormser, Vice President and Technical Director, Barnes Engineering Co.*

Passive infrared sensing systems appear to have an assured future in space navigation and observation. The thermal radiation constantly emitted by the planets and their atmospheres is already being used for attitude sensing and for meteorological charting of radiation patterns.

In addition, IR instruments have been designed for terminal guidance for planet landings. For example, instruments have been built that can home in on the IR radiation emitted by Venus and Mars from 100,000 miles out and guide a spacecraft to within 5000 miles of the planet surface.

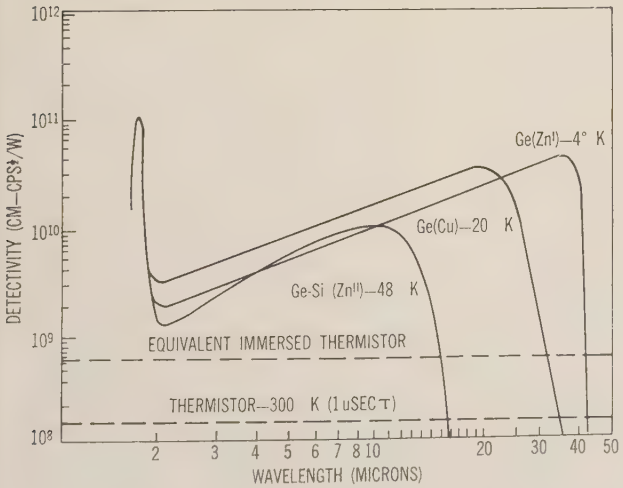
DEPENDING ON the nature of a planet's atmosphere, the thermal radiation that is continually and passively emitted by the planet is determined by the absolute temperature either at the top of the atmosphere or at the surface of the planet (*Table I*). Emitting surface temperatures range from 120 to 400 deg K, which means most of the radiation falls in the infrared region of the spectrum at wavelengths longer than five microns. To sense this type of radiation, infrared detectors with appreciable sensitivity in the 5-40 micron region are required.

Two kinds of IR radiation are received at a space craft from a planet:

- directly emitted thermal radiation;
- diffusely reflected solar radiation.

Direct radiation depends on the temperature of the planet's surface and on the temperature, composition, and density of its atmosphere. The thermal radiation of planets with relatively dense atmosphere, (e.g., the earth, Venus, and Mars) is relatively constant and uniform over the planet's surface. Planets or satellites with very tenuous or no atmospheres, (e.g., the moon) undergo larger temperature cycles.

* Barnes Engineering Co., Stamford, Conn.



IR Detectors

Photoconductive and thermal IR detectors are available for the spectral region from five to 40 microns. The Graph compares the spectral response and sensitivity of recent impurity-doped germanium photoconductive detectors with that of thermistor detectors for a detectivity measured under standard conditions—a bandwidth of one cps and with the IR source "chopped" at 900 cps.* The photoconductors require cooling to very low temperatures, only a few degrees above absolute zero—a formidable problem in a spacecraft. Cooling by radiation exchange with the space background has been considered but is not yet feasible.

Thermal detectors operating at ambient temperatures, while less sensitive, are more practical today. Solid-backed thermistor bolometers, for instance, are small and rugged, have fast response, and are reasonably sensitive. They can be made with sensitive areas from 0.1 to 10 mm in linear dimensions.

* S. I. Jacobs, "Characteristics of Infrared Detectors;" Electronics, Apr. 1, '60. R. C. Jones, "Phenomenological Description of Response and Detecting Ability of Radiation Detectors;" Proc. IRE, Sept. '59.

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From precision components, the periscope assembles easily with only spanner wrench and screwdriver. A large assortment of varying tube lengths, elbows, eyepieces, and objectives, permit construction of numerous configurations. Completed periscopes can be reassembled into entirely different configurations to provide wide applicability.

Kollmorgen modular periscopes feature:

- Low purchase price.
- Erect images at any angle of bend.
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- Easy mounting through, over or around walls, barriers, any viewing obstacles.
- Full warranty backed by fifty years of Kollmorgen quality in optical/electronic/mechanical systems.

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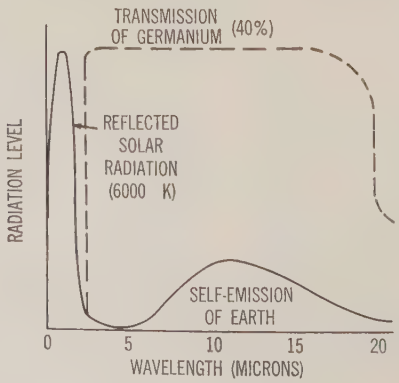
Table I: Infrared Radiation Emitted by the Earth and Nearby Planets

Parameter	Earth		Moon		Venus		Mars	
	Surface	Top of Atmosphere	Bright Side	Dark Side	Surface	Top of Atmosphere	Equator	Poles
Temperature (deg K)	290	220	400	120	430	225	280	205
Peak Wavelength of Radiant Emitted Energy (microns)	10	13	7.5	24	7	11.5	10	14
Total Radiant Energy ($W-cm^{-2}-St^{-1}$)	0.013	0.0047	0.00047	0.0004	0.063	0.005	0.011	0.003
Energy between 1.8 and 18 Microns (per cent)	66	47	82	9	85	49	64	42
Energy between 7.5 and 18 Microns (per cent)	56	45	54	9	52	46	56	41
Relative distance from Sun	1.0		1.0		0.72		1.52	

The reflected solar radiation from any part of a planet varies greatly as a function of time, depending on the position of the spacecraft and also on the albedo of the given region of the planet. This albedo in turn depends on the nature and height of clouds over the region.

There is a sharp thermal discontinuity between the planet horizon and the space background, since the thermal radiation from space is essentially zero. To determine the orientation of a spacecraft with respect to a planet and measure the vehicle's distance from it, therefore, you can establish the planet horizon by sensing the discontinuity.

FIGURE 1: Rejection of solar radiation by germanium optical elements.



To sense the horizon-space discontinuity reliably and minimize false indications from sharp visual discontinuities on the planet surface, the horizon sensor should respond only to energy in the thermal-wavelength region. An IR detection system can be made relatively insensitive to reflected sunlight—which has 95 per cent of its energy at wavelengths shorter than two microns (*Fig. 1*)—with an optical element or filter of pure germanium. A system with such elements and thermistor detectors is sensitive only to radiation in the thermal region (1.8-18 microns).

The vehicle is stabilized by controlled spin

The simplest method of controlling the motion of a satellite is to launch it with a controlled spin, which continues in orbit and stabilizes the vehicle in inertial space. In orbit, the orientation of the spinning satellite changes continuously with respect to the earth. This change can be monitored by a simple IR horizon-sensing device.

The Tiros I and II satellites were given a spin about their axis, and both carried a small, radially

Lanyard-operated switch withstands 92 G's at 2000 cps

SPECIFICATIONS

Type M-479-1

Spring Actuated Switch

Type... 4-pole, double-throw

Current capacity... 10 amps. each circuit

Voltage drop across contacts at 10 amps., 28 v.d.c.... under 50 millivolts

Weight... 0.5 lbs.

Length, excluding leads... 2.7 inches

Diameter... 1.6 inches

Life... exceeds 5000 cycles minimum

Environment... meets MIL-E-5272

For extremely rigorous missile environments with shattering vibration as high as 92 G's rms at 2000 cycles, Kinetics Corporation has developed a new lanyard-operated switch. Absolute reliability is assured, even when the unit is installed in locations subject to maximum acoustic vibration or white noise.

The new four-pole, double-throw switch combines the unique Kinetics contact design with a plunger and spring operating mechanism for position stability. In one current application, a lanyard attached to the ground holds the switch in one position. When the missile lifts off the pad, the lanyard is pulled, actuating the switch.

This new switch, which has been designated Type M-479-1, has just passed a severe testing program with flying colors. It was exposed to high level sinusoidal and random noise vibration tests in both axes in the normally open and closed positions without contact movement or chatter. The highest vibration level the switch has passed to date has been an equivalent 92 G's rms at 2000 cps. Testing was carried out at frequencies from 50 to 2000 cps. If required, switches of this design can be built to withstand even greater vibration.

This Kinetics switch design lends itself to a wide variety of missile applications, such as actuation upon missile launch or stage separation. It can also be used as a limit, timing, or function switch for range safety, power or instrumentation. For help with your switch requirements, write or phone Kinetics Corporation, Dept. KS-8, 410 South Cedros Avenue, Solana Beach, Calif. SKyline 5-1181.

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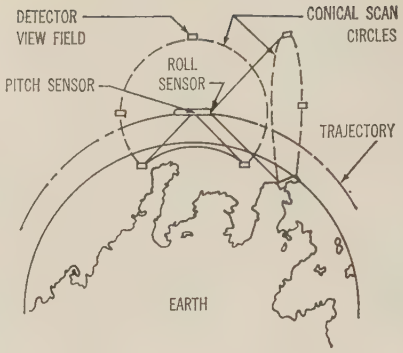


FIGURE 2: Orthogonal scanning for establishing vertical planes in pitch and roll axes of spacecraft.

mounted IR sensor (*Fig. 8*). This compact unit has a one-inch germanium lens, an immersed thermistor detector, and a transistor amplifier.

The Tiros I's IR sensor showed occasional, sharp thermal discontinuities over areas on the earth other than at the horizon. These discontinuities, which limited the usefulness of the horizon sensor, occurred both during the day and at night and are believed due to the contrast in the 8-13-micron atmospheric transmission region that arises as the sensor scans from sharp, cold cloud edges onto relatively warm earth. Recent high-altitude balloon flights show that the contrast level of such discontinuities can be as much as one-third of that of the earth-space horizon.

Spurious discontinuity signals of this kind can be avoided by restricting the spectral response to a strong atmospheric absorption region, such as the broad CO_2 and water-absorption region above 15 microns. This limits the response

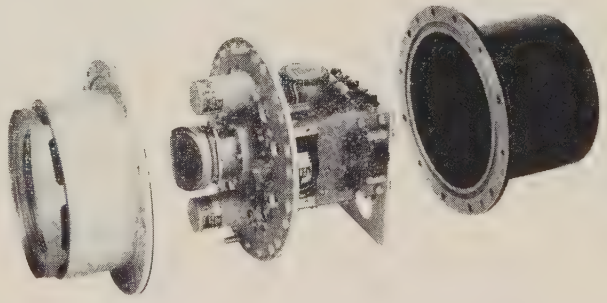
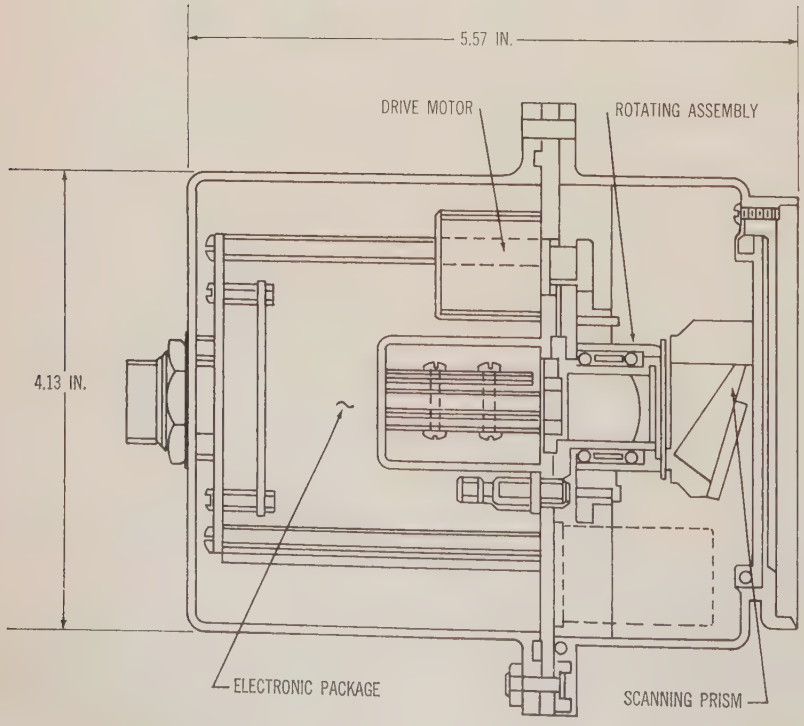
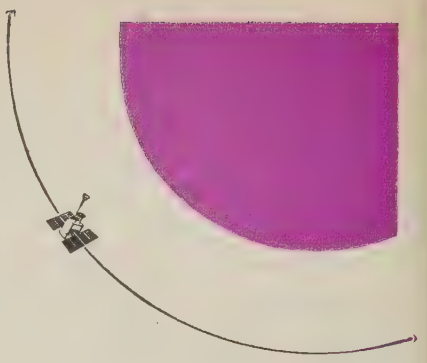
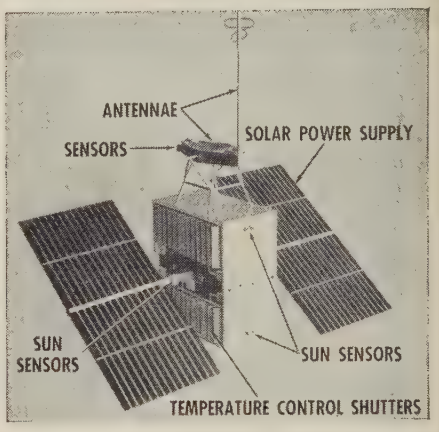


FIGURE 3: Cross - section and exploded view of twin-axis horizon sensor using rotating prism scan.





ADVENT



To create a worldwide communications system, three ADVENT satellites could be spaced equidistantly in an equatorial orbit. Each satellite, orbiting at 7000 mph, could hover in a constant position relative to the Earth, in direct line of sight of approximately one-third of its surface. ADVENT is being developed for at least one year of effective in-orbit operation. General Electric's Missile and Space Vehicle Department is developing and building the ADVENT space craft and the following subsystems:

Tracking and Command to provide position and orbit information.

Propulsion to inject the ADVENT satellite into its correct orbit.

Power to operate the communications and all other equipment—from solar energy harnessed by several thousand solar power cells; and from storage batteries for operation during eclipse.

Attitude Control to orient ADVENT's solar cell paddles toward the sun and its antennae toward the Earth.

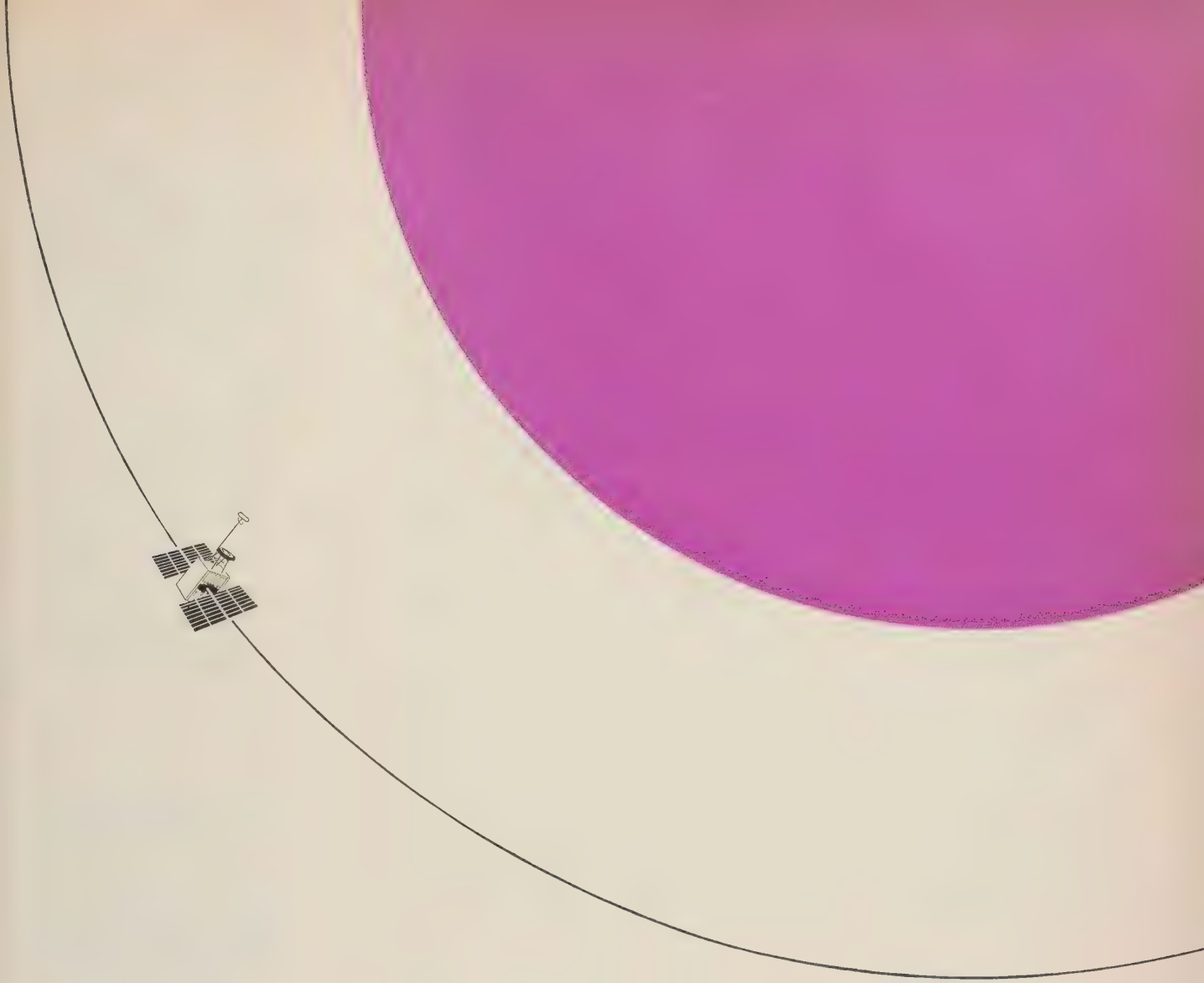
Environmental Control to keep equipment operating at the stable temperature necessary to fulfill the long-life requirements.

Telemetry to provide continuous transmission of data on equipment performance.

MSVD, a department of the General Electric Defense Electronics Division, is developing the space craft for the U.S. Army ADVENT Program under a contract with the USAF Space Systems Division.

160-02

GENERAL ELECTRIC



ADVENT is designed to be America's most advanced military communications system. Three active repeater satellites, orbiting at 22,300 miles in space, can provide instantaneous communications among U.S. government activities throughout the world. To help prove overall system feasibility, General Electric's Missile and Space Vehicle Department is developing the ADVENT space craft for the U.S. Army, under the direction of the U.S. Air Force.

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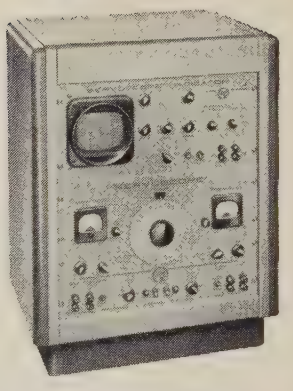

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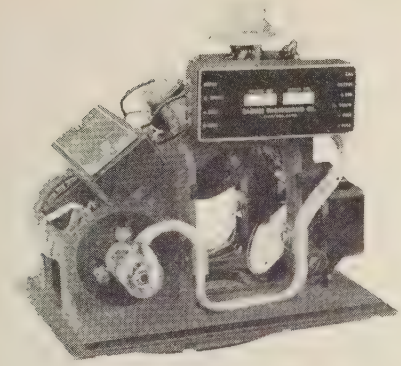


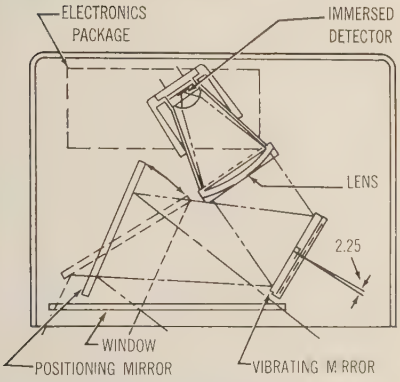
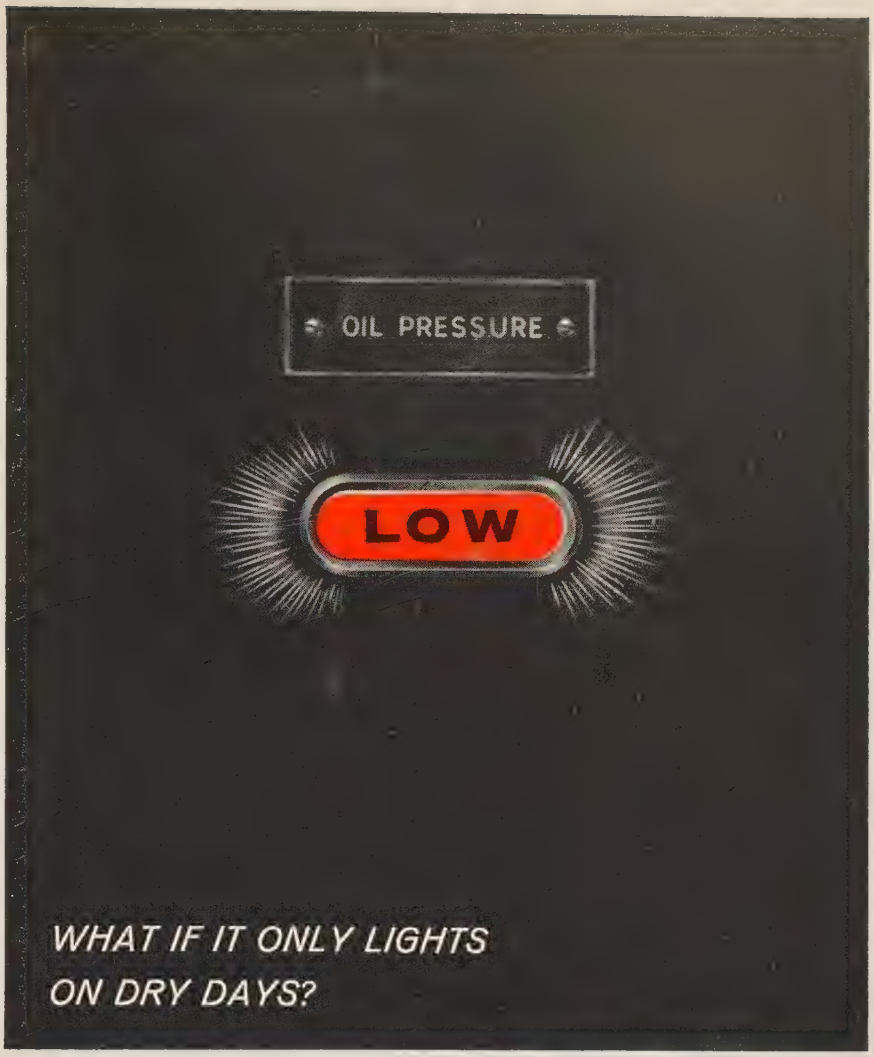


FIGURE 4: All-altitude horizon sensor with cover removed and in cross-section.

to emission from the top of the troposphere and calls for detectors and optical systems with long-wavelength response. To establish vertical planes in the pitch and roll direction of spacecraft that must be precisely oriented, a light, compact IR horizon sensor system has been developed. Two identical sensors are mounted perpendicular to each other (*Fig. 2*). Each consists of a scanner that rotates the projected image of a small thermistor IR infrared detector, scanning space and a segment of earth below the satellite. The scanner senses the transition from cold space to warm earth and vice versa. The detector outputs are fed to a circuit that determines the midpoint between the two horizon transitions regardless of any temperature differences at the horizon points.

The scanner, made up of a scanning system and transistor electronic circuits, is mounted in a sealed, flanged unit with a germanium window. The scanning system includes the optics and the mechanism for sweeping the detector's field of view across earth and space (*Fig. 3*). An immersed thermistor detec-



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The *one* way to be sure about a pressure switch is to test it through the whole range of operating requirements . . . not just at 0% humidity or just at room temperature.

Take Model 6547 shown at right which serves in many ways . . . cabin pressure alarm, landing gear position signal, electronic equipment operation, acting parallel to an altimeter. This pressure switch has a calibration accuracy of 20 mm Hg from −65° F to 250° F, 0 to 100% humidity, with an actuation range of 2,000 to 20,000 and 15,000 to 70,000 feet. It weighs only 5½ ounces.

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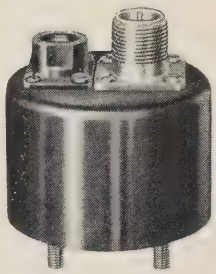
Or you can save yourself six weeks by examining our own test data on a full line of pressure switches for the type that meets your needs best. Call Mr. Charles Colt at Consolidated Controls, Bethel, Conn. Phone Pioneer 3-6721, DDD Code 203.



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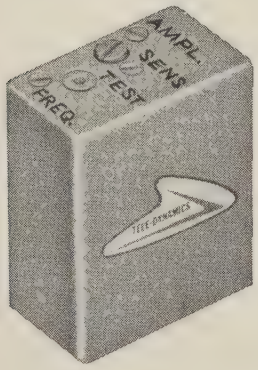

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Environmental characteristics include thermal stability of ± 1.5% design bandwidth from —20°C to +85°C, unlimited altitude, 30G random vibration and 100G acceleration and shock. The 1270A weighs less than two ounces and has a volume of two cubic inches.

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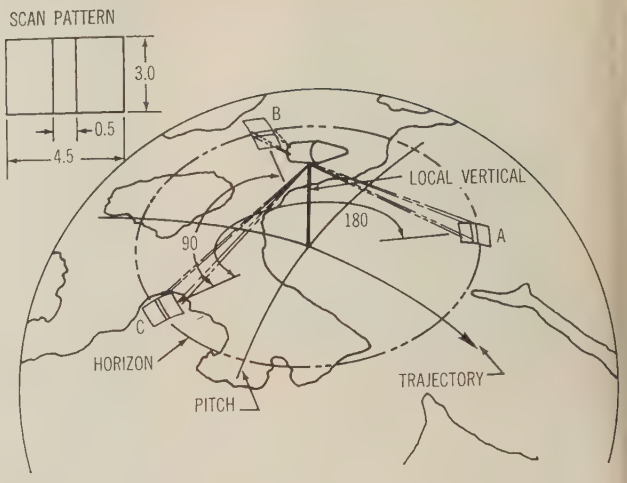


FIGURE 5: Spatial arrangement of three axes of all-altitude horizon sensor. Three patterns are scanned simultaneously.

tor is secured to the center of a large, circular plate. The scanning prism deflects its 2x8-deg view-field at a 55-deg angle from the normal. As the drive motor rotates the prism at 30 RPS, the detector field transverses the earth once in the course of each revolution, producing a 30-cps rectangular-wave signal. Pitch (or roll) information is obtained by comparing the phase of the signal with that of an internally generated reference signal.

Horizon-sensing accuracy depends on circuitry

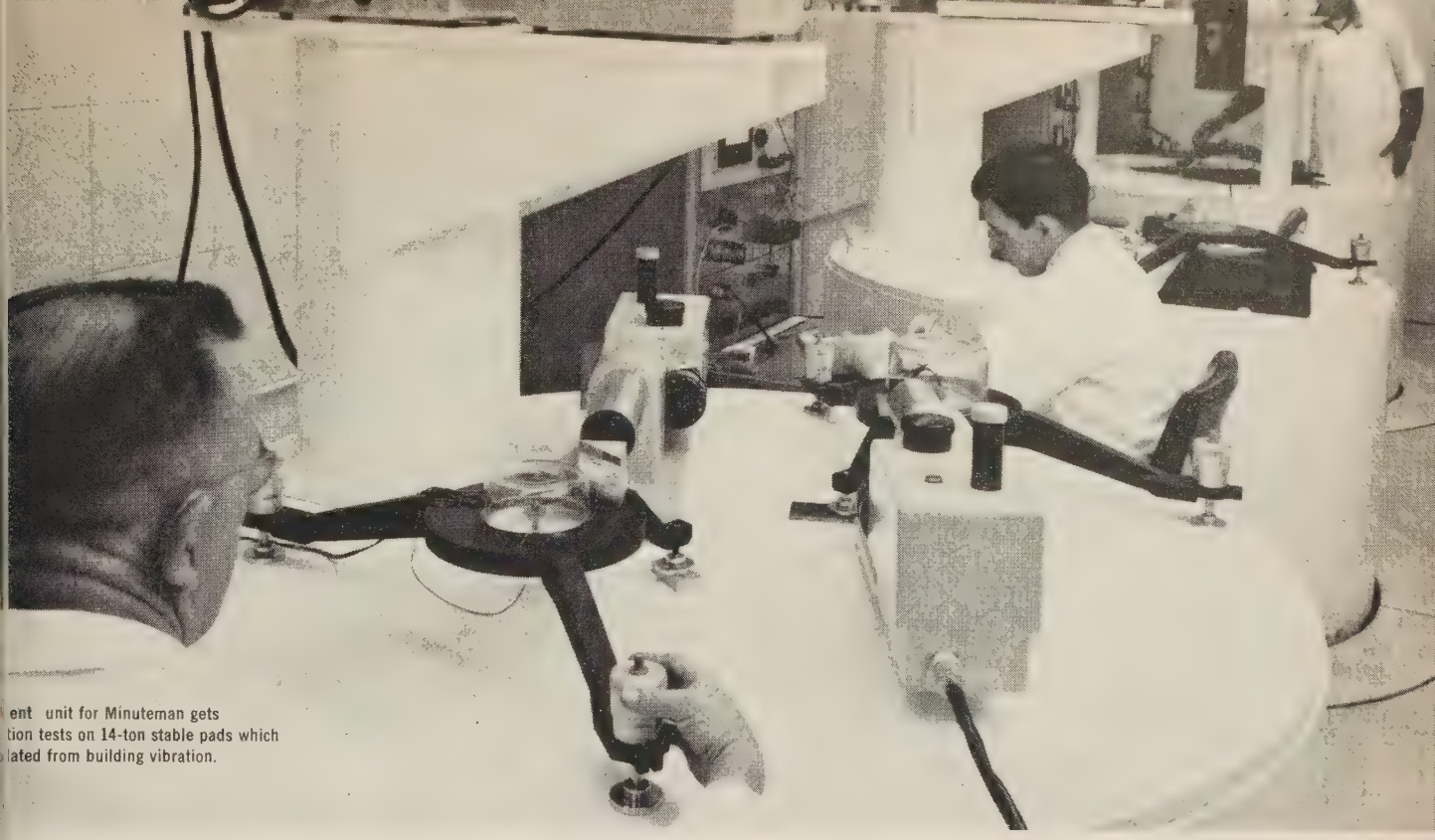
The output transfer function is linear over a tilt range of ±35 deg and remains at a constant maximum for tilts up to ±90 deg. The absolute accuracy of horizon sensing varies from ±1 to ±0.1 deg, depending on the complexity of the electronic circuit.

Units of this type provided stabilization sensing for the Atlas and Thor nose cones that produced remarkable high-altitude photographs. In a Jupiter test, this horizon sensor determined the local vertical within ±¼ deg at altitudes of over 60 miles. This performance compares well with that of a high-quality inertial platform. IR horizon sensors have also performed successfully in several Mercury test flights, including the one made by Comdr. Alan B. Shepard.

In satellites that must remain in stationary orbits with respect to the earth, horizon sensors must operate from 60 miles up to the synchronous orbit height of 22,300 miles. A compact unit to meet this requirement has been developed for NASA-Marshall (*Fig. 5*). It has three sensors oriented 90 deg apart, and in each sensor a thermal detector image subtending 0.5x3.0 deg is oscillated 4.5 deg in a radial direction by a vibrating-mirror scan system (*Fig. 7*). A servo-driven positioning mirror centers each of the oscillating scans on the horizon discontinuity with an accuracy of 0.1 deg. Pitch, roll, and altitude above the earth are com-

Table II: Channels of Tiros II AC Radiometer

Channel	Wavelength Ranges (microns)	Description & Function
I	0.2–5	includes 99% of incident solar radiation
II	7–30, 40	measures total IR emission; determines average black-body temperature
III	8–12	best atmospheric window; measures cloud and earth-surface temperatures
IV	5.6–7	strong water absorption band; measures temperature of top of troposphere
V	0.55-0.75	response similar to eyes; correlates with TV equipment in satellite



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tion tests on 14-ton stable pads which
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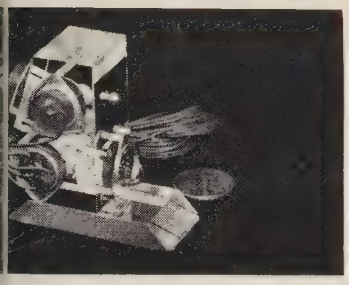
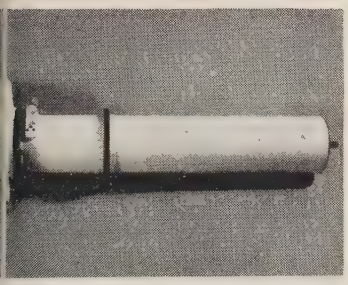
TI's ELECTRO-OPTICAL SYSTEMS CAPABILITY



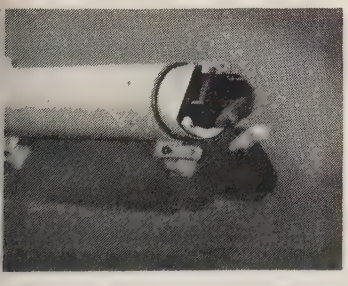
***MINUTEMAN**

Alinement Unit for the Autonetics Division of North American Aviation, Inc. These units establish the vertical reference of Minuteman missile . . . level detectors sense local vertical to an accuracy better than 1 second of arc. The quartz prisms on which the detectors are mounted have angular tolerances of less than 2 seconds of arc and surface flatness of ¼ wavelength of light.



***NIKE-ZEUS**

Optical assembly for Bell Telephone Laboratories. For check of Nike Zeus radar alignment, the tracking system in which this assembly is used has a dynamic accuracy of better than 4 seconds of arc . . . can be adapted to operate in any part of the spectrum from the ultraviolet to the far infrared.



***POLARIS**

Optical deviator for Marine Equipment Department of Nortronics, a division of Northrop Corp. This electro-optical system checks the alignment of the navigation system of the Polaris bearing submarine. It deviates light 180 degrees and maintains accuracy of 2 seconds of arc even in severe vibration, shock and changing temperature environment.

Precision optics, electronics and **mechanics** are being combined at Texas Instruments into new high-accuracy alignment, calibration and tracking systems for advanced programs such as Minuteman, Polaris and Nike-Zeus. This capability began in 1956 when TI integrated complete optical facilities and the skills of veteran craftsmen with the company's total corporate capability which includes development of complex military electronic and mechanical apparatus plus basic and applied research and manufacture of ultra-pure optical materials and detectors. This unique technology has now been extended into the fields of navigation, stabilization, detection, tracking, communications and energy conversion. For information on your specific electro-optical requirements, contact MARKETING DEPARTMENT.

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New plant and plastic will provide quality uniformity with volume . . . many advantages for processors and users

The New Product

- KEL-F 81 Plastic . . . retains the excellent end-properties of the original, but offers completely new processing advantages made possible by new manufacturing techniques and facilities.
- KEL-F 81 Plastic features exceptional consistency and uniformity . . . *not only within each lot, but from lot to lot as well.*
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- Consistency in processing conditions provides a further uniformity standard for KEL-F 81 Plastic.
- KEL-F 81 Plastic is available in several forms to provide highest adaptability to customers' processing.

The New Plant

- Now on stream at Decatur, Alabama . . . newest, most modern chemical plant devoted exclusively to the production of quality fluorochemicals.
- Latest processing and quality control equipment, designed by one of the pioneers in fluorochemistry and fluorochemicals production.
- Production versatility that can move swiftly from pilot stage to full production of products adaptable to a wide range of customers' needs.
- Entire operation specifically designed to ensure highest uniformity in 3M Fluorocarbon chemicals.
- An integrated system of rail, truck and waterway transportation will provide fast delivery for your fluorochemical needs.

The big new 3M plant alongside the Tennessee River is now on stream with high-volume quality production of 3M Fluorochemicals to meet the expanding demands of industry. Featured are . . .

New Processing Advantages

One of the major products to be produced by the new plant is "KEL-F 81 Plastic" . . . chemically similar to previous KEL-F products, but now available with substantial revisions in processing advantages . . . for use in many industrial applications . . . especially in electrical, electronic, aero-space, and many chemical processing plants as a resilient, dense thermoplastic molding material, with product improvements you will welcome. For example . . .

Assured Uniformity!

In 3M's new Decatur plant, every precaution has been taken to ensure the highest uniformity of quality for KEL-F 81 Plastic production . . . both within a lot and from one lot to another.

Qualified processors will be offering KEL-F 81 Plastic in a variety of physical forms, each tailored to specialty requirements of product or process. They will meet exceptional degrees of resistance to chemical attack, heat, cold, moisture, dielectric properties, etc.

Stepped-up Fluorochemicals Production

3M—Decatur not only will manufacture KEL-F 81 Plastic . . . it will produce the full line of chemical products carrying the KEL-F brand name . . . plastics, elastomers, dispersion coatings, greases, oils and waxes.

Accelerated Delivery!

A completely integrated network of transportation will serve the Decatur plant, helping 3M give industry fast delivery of KEL-F Plastic and other products in the fluorochemical family. Railroad lead tracks and newly constructed highway arteries, with automatic loading facilities will speed these products to customers.

Technical Help!

3M technicians as well as a technically oriented sales force stand ready to provide practical technical help to manufacturers seeking to apply the advantages of KEL-F Halofluorocarbon Products to their applications. Their services (based on extensive field and laboratory tests) as well as 3M lab facilities and services of qualified processors will be available for help in overcoming problems involving the use of any of these products.

Production Assistance!

3M sales and lab representatives offer a wealth of experience with fluorochemicals, to assist qualified processors in setting up efficient production procedures to better serve your needs.

New Technical Brochure!

Just off the press—a brand new brochure giving complete technical data on KEL-F 81 Plastic. It contains complete laboratory and test data on the chemical and physical properties of KEL-F 81 Plastic, (also processing details) together with much practical data on its use in compression, injection, transfer, and extrusion molding. Please write on your company letterhead, indicating the nature of your interest. Write: 3M Chemical Division, Dept. KAO-81, Minnesota Mining and Manufacturing Company, St. Paul 6, Minn.

KEL-F® 81 BRAND PLASTIC

"KEL-F" is a reg. TM of 3M Co.

Properties Profile

on

KEL-F® 81 PLASTIC

BRAND

KEL-F 81 Plastic is a fluorocarbon plastic, a thermoplastic resin formed by the homo-polymerization of chlorotrifluoroethylene. The high degree of fluorination of KEL-F 81 Plastic is responsible for its chemical inertness and thermal stability. The inclusion of chlorine in an otherwise carbon-fluorine molecule results in exceptional moldability and mechanical toughness.

Crystallinity. KEL-F 81 Plastic is crystallizable, but not necessarily crystalline, the degree and kind of crystallinity in a given sample being a function of its thermal history. The "quick quenched" resin is spoken of as amorphous, and the "slow-cooled" resin as crystalline. When crystalline, KEL-F 81 Plastic is a denser, more translucent material with higher tensile modulus, lower elongation, and greater resistance to the penetration of liquids and vapors. The amorphous plastic is less dense, more elastic, with greater optical clarity and toughness.

Physical Properties. The physical properties of KEL-F 81 Plastic combine mechanical, chemical, electrical, and optical advantages. And the most useful applications center around combinations of the following properties:

1. Useful temperature range: from –400°F. to +400°F.
2. Resistance to deformation and flow at high temperatures, pressures
3. Zero moisture absorption
4. Abrasion resistance
5. Radiation resistance
6. Chemical resistance
7. Electrical properties
8. Infra-red transmission
9. Inert to liquid oxygen
10. Flexible in contact with cryogenic fuels

Processing. KEL-F 81 Plastic can be processed in the same manner as other thermoplastic resins. Parts of KEL-F 81 Plastic may be specified in any form. However, because of time and temperature limitations, compression molding is the ideal method for retaining all of the desirable mechanical properties originally built into the basic polymer. Other processing methods, such as injection molding and extruding can be used to achieve the same degree of quality, but special attention to processing techniques is required to avoid excessive degradation.

Detailed discussion of these various processing methods, as well as the finishing of parts is contained in the free brochure, offered in the adjoining column—write for it!

CHEMICAL DIVISION

MINNESOTA MINING AND MANUFACTURING COMPANY

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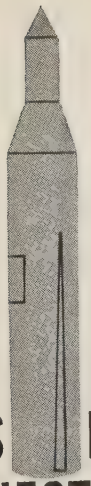
3M COMPANY



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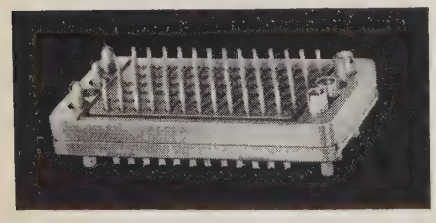

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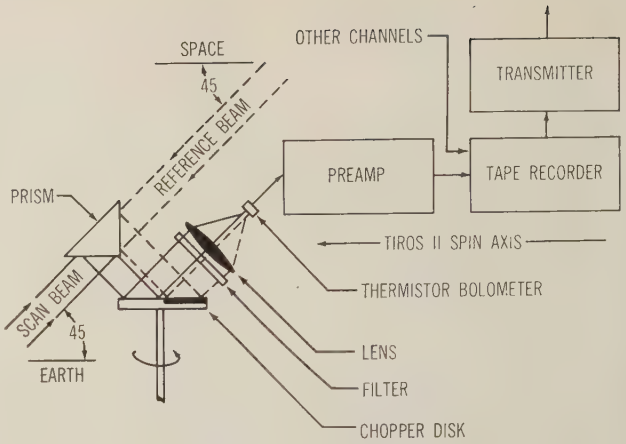

FIGURE 6: Basic arrangement of one channel of five-channel AC IR radiometer. Radiation from the earth is compared to the absolute zero of outer space.

puted from the angular measurements of the three sensor heads. With larger mirror optics, a unit of this type can be used for horizon-scanning of the moon for lunar orbits and landings.

Figure 6 shows an IR scanner for terminal Venus and Mars probes. Such a probe would be guided to within a terminal range of 100,000 miles by radio-inertial methods. At this distance, the planet orientation can be assumed to be known within ±35 deg. The planet therefore must be acquired within a view field of 70 deg. At about 100,000 miles, Venus subtends 4.3 deg and Mars 2.4 deg. The scanner is designed to provide accurate orientation information to a minimum orbit altitude of 5000 miles, at which Venus subtends 52 deg and Mars 35 deg.

Atmosphere of Mars is tenuous

The top of the dense Venusian atmosphere is at 225 deg K, a temperature similar to earth's. Mars, on the other hand, has a tenuous atmosphere, and the long-range distant radiation from its surface ranges from 280 deg K above the equator to 205 deg K above the poles. The IR radiation from both planets can be detected at large distances by a compact scanner using only one sensor for acquisition and orientation.

The scanner contains counter-rotating prisms that sweep the thermistor detector's ½x½-deg view field through a four-looped rosette pattern 70 deg in diameter. During a search for the planet, the entire pattern is rotated through approximately 90 deg. When the planet is acquired, the pattern rotation is stopped, and the stationary rosette scan provides the orthogonal information from the single detector that determines the roll and pitch error. When the scan intersects the horizon, the thermal discontinuity between planet and space twice generates a rectangular wave in the course of each lobe scan. Pitch and roll information is extracted from the alternate pulses, establishing the orientation of the probe vehicle within 0.1 deg.

Meteorologists are eager for cloud-cover data

To learn more about meteorological processes, to make better forecasts' and perhaps eventually to control the weather, the meteorologists are eager to get continuous data on the cloud cover and the radiation exchange over the earth's entire surface. These data can best be obtained by instrumented satellites in controlled orbits. The Tiros II's non-scanning and scanning IR sensors are already supplying data on earth-space thermal radiation patterns. The non-scanner is a two-channel, wide-field DC radiometer; the scanning sensor, a five-channel, narrow-field AC radiometer.

The two-channel DC instrument is aimed parallel to the satellite spin axis and has a 50x50-deg view field. Each channel has its own radiometer with a small thermistor mounted at the apex of a radiation-collecting cone. One of the radiometers has a "black" flake, which absorbs both visible and IR radiation, while the other has a "white" flake, which absorbs only long-wavelength IR. The output of the first radiometer is a function of solar radiation incident on the

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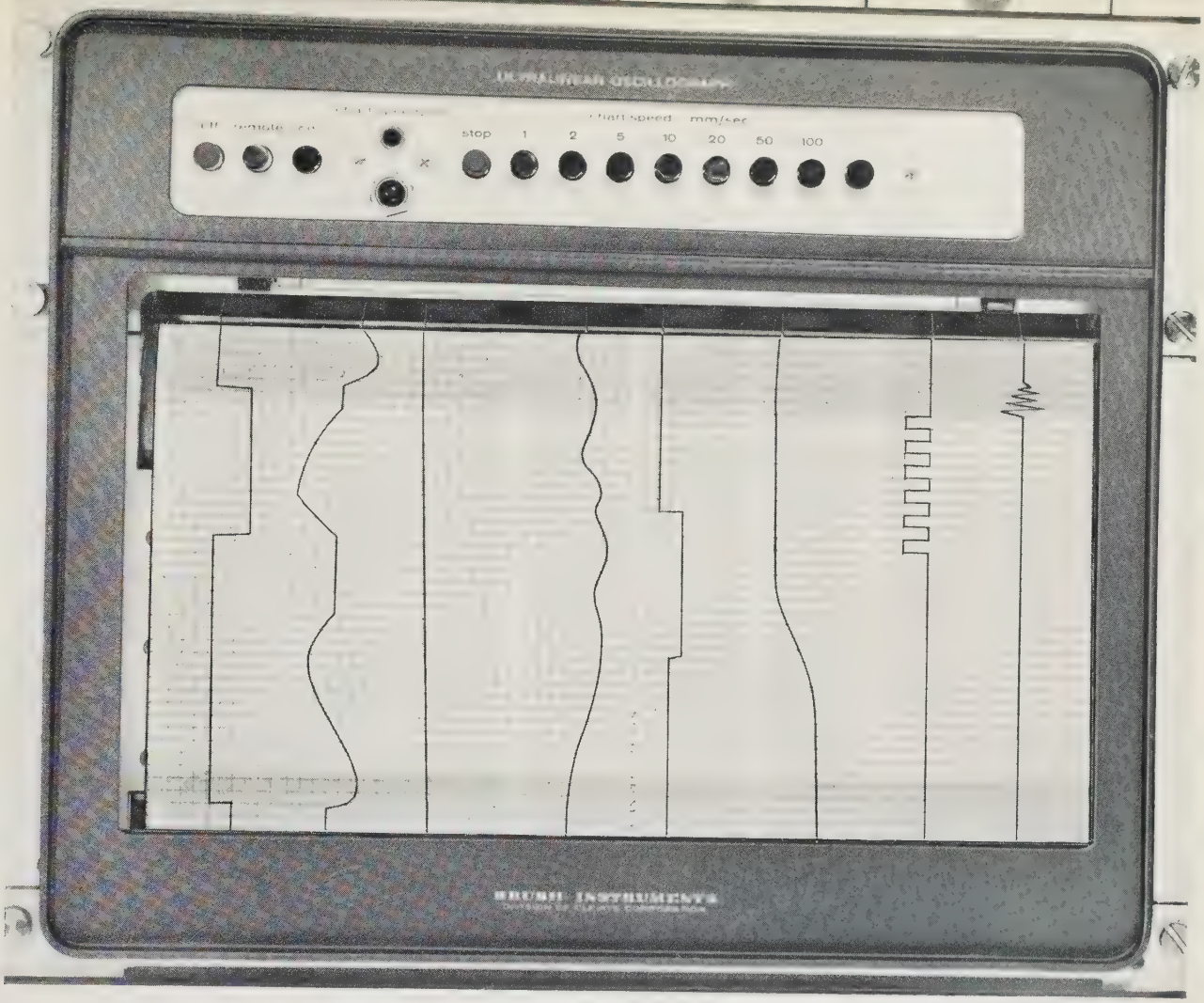

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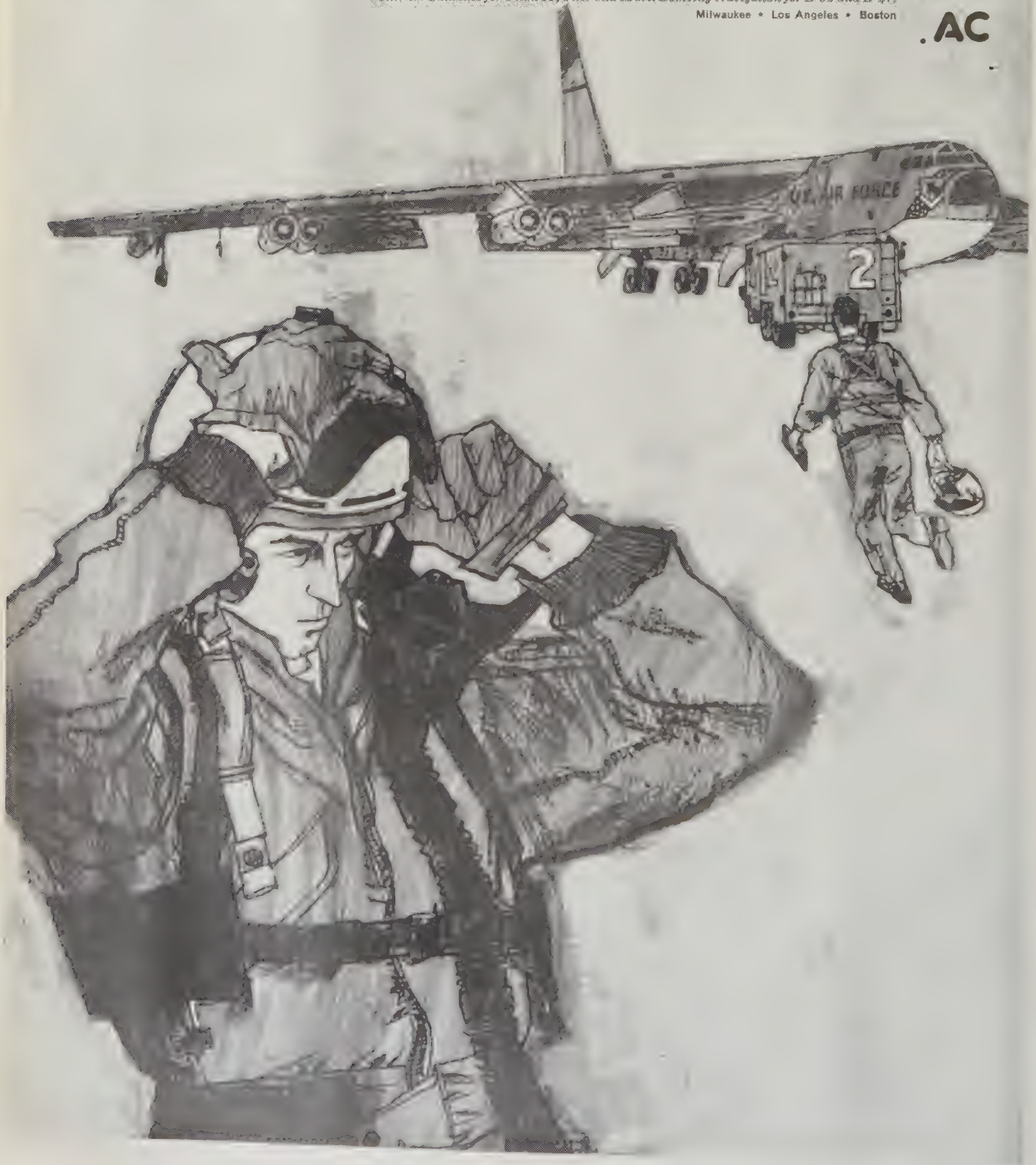

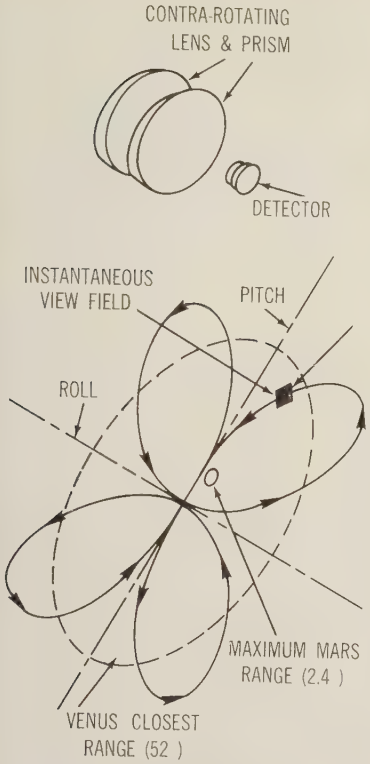

FIGURE 7: Scan pattern used by single detector sensor for planet acquisition and spacecraft orientation.

viewed portion of earth, while the output of the second represents only the thermal radiation from the same area.

The five-channel AC radiometer is mounted at 45 deg to the spin axis and scans a circular arc about 35 miles wide. In a conventional AC radiometer, measured-source radiation is compared to that from a reference black body of known temperature.[1] In a satellite, however, an integral black body is ruled out by temperature compensation problems. The Tires II AC radiometer (a NASA-Goddard design) therefore uses interstellar space, which is essentially at absolute zero, as the reference level.

In this device, half-absorbing and half-reflecting a scanning disk alternately switches the earth scan beam and a space reference beam onto a small radiation receiver (*Fig. 9*). Its detector output is an alternating signal proportional to the radiation from the scanned portion of earth as compared with the absolute zero of space.

(1) R. W. Astheimer E. M. Wormser, "High-Speed Infrared Radiometers;" Opt. Soc. Am., Feb. '59.

For more than 40 years, Kidde engineers have designed and made thousands of pressure vessels in a multitude of shapes, materials, capacities and strengths. Today, with pressure vessels an important part of missile or rocket programs, it's only logical that engineers rely on Kidde experience.

Kidde pressure vessels range from doorknob size to 3500 cubic inches capacity; from a life of 10 cycles to 500,000 cycles; pressures up to 20,000 psi. Kidde pressure vessels are made in steel, fiberglass, aluminum —welded or drawn—wire wound—minimum weight for application. Configurations are practically limitless—including cylindrical, spherical, conical, torus. Many are available on an off-the-shelf basis!

In addition to solving current problems in pressure vessel applications, Kidde engineers are also hard at work advancing today's techniques to solve tomorrow's problems. So, if pressure vessels have you stumped, why not call on Kidde for the answer . . . most people do!

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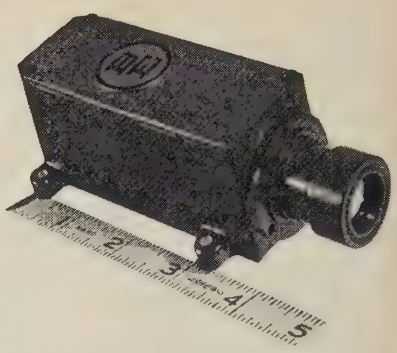


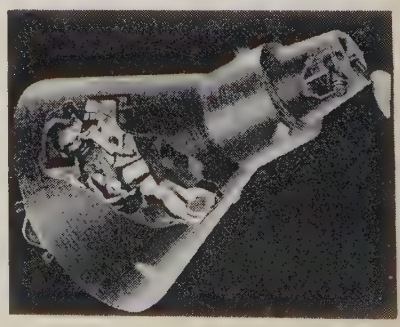
FIGURE 8: IR sensor for horizon discontinuity detection.

The scanning radiometers have an instantaneous 5x5-deg view field, which at 400 miles altitude subtends a 35x35-mile area. As the satellite spins at this altitude, the five-channel radiometer traces a nearly circular arc 35 miles wide and 800 miles in diameter. The five channels of the radiometer look simultaneously at the same area, sampling various bands of radiation (*Table II*).

Kaplan has suggested that it should be possible to compute a vertical temperature profile of the atmosphere by simultaneous measurements—from a satellite above the atmosphere—of the IR energy emitted by several narrow bands of varying emissivity of a gas that is uniformly mixed in the air (e.g., CO_2).[2] Depending on the emissivity of the spectral band under examination and the transmission of the atmosphere for that band, a spectrometer focused on spectral intervals of about 0.1-micron width within the broad CO_2 absorption region (14-17 microns) will receive energy from layers of varying depth as seen from above the atmosphere.

(2) L. D. Kaplan, "Inference of Atmospheric Structure from Remote Radiation Measurements;" Opt. Soc. Am., Oct. '59.

HORIZON sensors in Mercury capsule.



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Splices in aircraft and missile circuitry must be dressed to weather the most withering kinds of high-altitude temperatures, moisture, vibration, shock, corona. AMP INCORPORATED splices **are** dressed for it, no matter what the environmental threat. High-altitude heat? AMP's **STRATO-THERM** (A) line of splices are designed to keep circuits intact at continuous temperatures to 1200°F. The post-insulated Strato-Therm splice (illustrated) has a Teflon* outer sleeve and silver-plated electrolytic copper inner sleeve, plus metal crimping rings, for full circumferential protection to solid, stranded or combination conductors. Splices available in materials to resist effects of high energy fuels compounded with Hydrazine and for connecting Chromaloy and Alumel cables. AMP's positive compression crimp insures electrical soundness. The insulated Strato-Therm splice is ideal for temperatures up to 550°F.

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CLIMATE FOR CREATIVITY—Honeywell Aero is now producing inertial platforms for the Polaris Missile. In addition Aero Division Engineers have created an Electrically Suspended Gyro for use on Polaris launching submarines, which is capable of providing accuracies never before achieved in an inertial navigation system. This project is typical of the creative concepts and ideas which are being evolved and further developed into working hardware at Honeywell Aero. We invite you to share in this creative atmosphere where there is ample opportunity for a man of imagination, drive and talents to grow in professional stature and have his accomplishments recognized and rewarded.

CLIMATE FOR ENJOYMENT—Spectator or participant, you'll find whatever sport interests you in the Minneapolis area. For example, this is the heart of America's finest fresh water fishing country. At the end of a busy day or week you can angle for pike, bass, trout, or scrappy panfish in the more than 80 lakes within 25 miles of Minneapolis. Fishing is just one aspect of the many recreational, educational, social, and cultural pleasures you and your family will enjoy when you work at Honeywell's Aeronautical Division in Minneapolis. For information on specific openings, write: Mr. Clyde Hansen, Technical Director, Aeronautical Division, 2662 Ridgway Road, Minneapolis 40, Minn.

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To explore professional opportunities in other Honeywell operations, coast to coast, send your application in confidence to: Mr. H. T. Eckstrom, Honeywell, Minneapolis 8, Minn.
All qualified applicants will receive consideration for employment without regard to race, creed, color, or national origin.

Check Inquiry Form on Page 145

Space/Aeronautics

CONFIDENTIAL

August 1961

(good until 10/15/61)

Employment Inquiry Form

(Not an application for employment)

THIS INQUIRY FORM is a service that makes it easier for the interested reader to explore employment opportunities with organizations featuring recruitments advertising **in this issue.**

To use this Form, follow these simple steps:

(1) Tear out this page.

(2) Check off the organization(s) listed below whose employment offers are of interest to you. **Use typewriter or pencil.**

(3) Turn to the back page of this Form and answer the questions on it.

(4) Mail this Form (in a stamped envelope) to:

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SPACE/AERONAUTICS
205 East 42nd St.
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We will do the rest and promptly forward a copy of your Inquiry Form to each of the organizations you have checked. Depending on their specific personnel requirements they will get in touch with you at your home.

I am interested in the employment opportunities at:

- ☐ Aerospace Corp. 30
- ☐ AiResearch Mfg. Co. 153
- ☐ Boeing Airplane Co. 147, 148
- ☐ Convair; Astronautics Engineering Div. 165, 166, 167, 168
- ☐ Garret Corp. 153
- ☐ John Hopkins University; Applied Physics 152
- ☐ Lockheed Aircraft Corp.; Georgia Div. 152
- ☐ Minneapolis-Honeywell Regulator Co.; Aeronautical Div. 144
- ☐ Mitre Corp. 150
- ☐ Pratt & Whitney 151
- ☐ Singer, Inc., HRB 149
- ☐ System Development Corp. 108
- ☐ United Aircraft Corp., Pratt & Whitney 151

OTHER (Some organizations' recruitment advertising in this issue may have arrived too late for inclusion in the above list. If you are interested in the employment offers of any of these organizations, just note its name and the page number of its advertisement in this space. Please refer only to ads keyed to this form.): _____

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NOTE: If you have an immediate interest in any special employment opportunity advertised in this issue and would like to give more details about your qualifications than can be noted on this Form, we advise you to send your resume directly to the person or department given in the advertisement. We'd appreciate it if you'd mention SPACE/AERONAUTICS in your application.

Space/Aeronautics

CONFIDENTIAL

August 1961
(good until 10/15/61)

Employment Inquiry Form

Please type or print (with pencil)

(Not an application for employment)

FIELDS OF INTEREST (in order of importance, note the general fields in which you would like to work—e.g., basic research, dynamics, structures, rocket propulsion, electronic systems, pneumatics, testing, materials, production, ground support, etc.): _____

SPECIALIZED JOB EXPERIENCE (describe the specific technical areas in which you have worked—e.g., flutter, fatigue, fuel systems, circuit miniaturization, servo systems, hydraulic pumps, tool engineering, orbit mechanics, telemetry, data processing, wind tunnel testing, etc.): _____

JOBS AND EDUCATION

List your last 3 employers:

EMPLOYER	CITY & STATE	YEARS EMPLOYED	JOB TITLE OR FUNCTION

List your college and university degrees:

SCHOOL	YEARS ATTENDED	DEGREE

Special Training _____

PERSONAL DATA

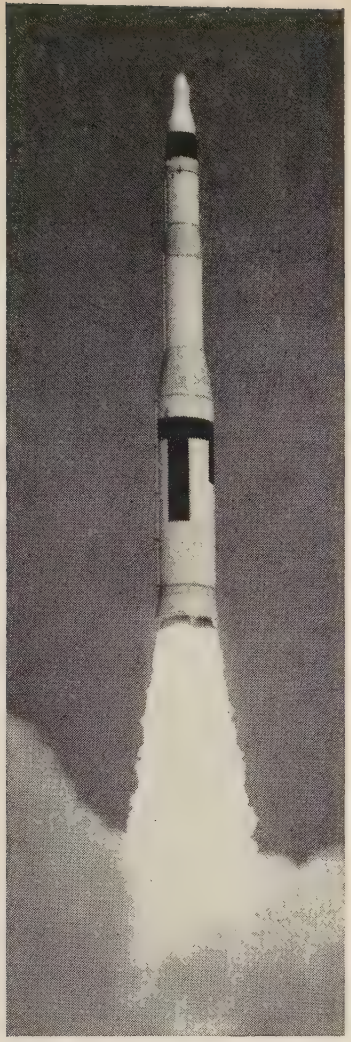
AGE ..... U. S. CITIZEN ☐ YES ☐ NO If not, when do you expect to become a citizen? .....

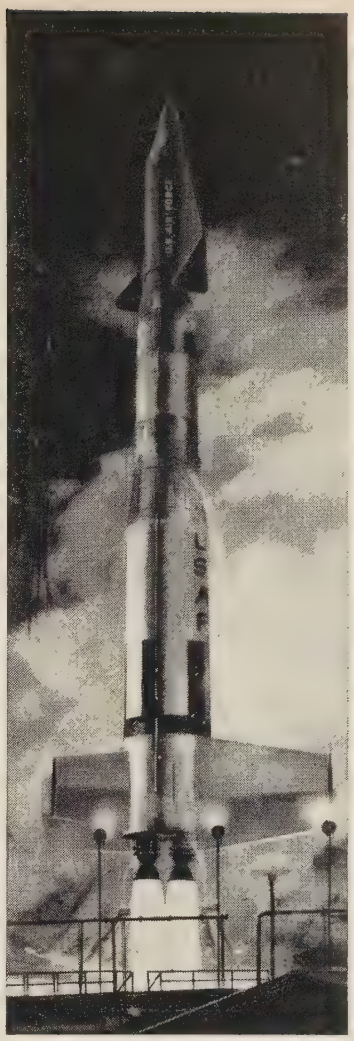
Name: .....

Home Address: .....

Home Telephone .....

Make sure you have checked the companies you are interested in on the other side of this Form. Then put the Form in a stamped envelope and mail it to **Space/Aeronautics**





Immediate Minuteman and Dyna-Soar openings for Electronic and Electrical Engineers

Electronics is one of the fastest growing areas of engineering at Boeing. Electronic and electrical engineers interested in the advancement of space-age technologies will find challenging and deeply rewarding opportunities in advanced Boeing programs, including the Dyna-Soar manned space glider and the solid-fuel Minuteman ICBM. Assignments exist in your particular area of interest and at the level you require for career satisfaction and advancement. For your convenience, a professional application form appears at the right, and continues on the following page.

MAIL FORM TODAY

RETURN TO: MR. W. B. EVANS
THE BOEING COMPANY
P. O. BOX 3707-SEB
SEATTLE 24, WASHINGTON

PROFESSIONAL POSITION APPLICATION
(All replies held in strict confidence)

Date of this Application_____

Name_____
LAST FIRST MIDDLE (USE NO INITIALS)

Social Security No._____

Present Address_____
NO. STREET

_____
CITY ZONE STATE

Telephone No._____

Ht._____ Wt._____ Age_____ U.S. Citizen_____

Male_____ Female_____ Marital Status_____

No. of Children_____ Other Dependents_____

U.S. Veteran_____ Entry Date_____

Discharge Date_____

Type of Discharge_____

Spouse's Maiden Name_____

Employer_____

Previous Boeing Employee?_____

If the answer to following three questions is "yes," explain on supplementary sheet:

1) Have you any physical defects?_____

2) Have you ever been arrested (except traffic and juvenile)?

_____

3) Have you ever received disability or accident compensation?_____

TURN PAGE

HIGHER EDUCATION

College and Location	Dates Attended	Degree and Major
1.		
2.		

EMPLOYMENT HISTORY (Attach Resume)

Firm Name and Address	Base Pay 40 hr/Wk	Dates Employed Month/Year
1.		
Position & Duties		
2.		
Position & Duties		
3.		
Position & Duties		
4.		
Position & Duties		

REFERENCES. Give full names, occupations and addresses. Professional (previous supervisor preferred):

1. _____

2. _____

Character (other than relatives or former employers):

1. _____

2. _____

LIST TYPE OF WORK PREFERRED UPON EMPLOYMENT:

_____

_____

Have you ever been cleared for classified military information?_____. If yes, give date, level and company.

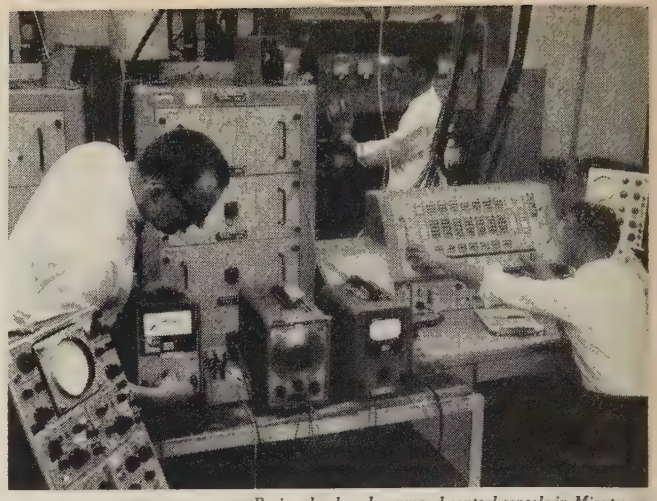
May we contact your former and present employer prior to completion of employment negotiations? Yes____ No____ If "yes," I authorize, without liability, the release of all employment and personal information.

_____
SIGN YOUR NAME HERE

All qualified applicants will receive consideration for employment without regard to race, creed, color or national origin.

RETURN TO: MR. W. B. EVANS
THE BOEING COMPANY
P. O. BOX 3707-SEB
SEATTLE 24, WASHINGTON

Form begins on previous page



Boeing-developed command control console in Minuteman Subsystem Test Laboratory, Boeing Developmental Center.

Electronic and electrical engineers will find unique opportunities at Boeing. Activities in research, design and test are making significant contributions to the state-of-the-art as well as to the development, manufacture and installation of systems associated with Dyna-Soar, Minuteman, Bomarc, advanced aircraft, and orbital vehicle programs.

Assignments encompass broad areas of electronics activities including surveillance, communications, guidance and control, systems engineering, systems integration, antennas, cabling, circuit design, electromagnetic warfare, electronic packaging, electronics ground support, instrumentation, radio frequency interference control, reliability, systems test, solid state circuit design and many others.

Exceptional opportunities exist for logical designers and for specialists in systems design; in data processing associated with telemetry, and in digital design techniques embracing circuit and systems design, miniaturization, test and evaluation of airborne computers and supporting ground electronics.

You'll find space in the application at the left to indicate your special interests. Fill in and mail today.

* * *

Sailing on 23-mile Lake Washington in Seattle.

Matching the career advantages at Boeing are the family living advantages of the Pacific Northwest. This uncongested, evergreen area is famous for mild, year-round climate, unexcelled recreational facilities, fine modern homes, excellent educational and cultural institutions and healthful outdoor Western living for the entire family.

BOEING

ATTENTION EMPLOYMENT MANAGERS

This new "Employment Opportunities" section allows you greater choice in positioning advertisements—in keeping with your recruitment objectives.

If the purpose of your campaign is to alert readers to immediate job openings you'll find the new section ideal for this need.

If, on the other hand, your aim is to acquaint readers with your organization—the scope of its operation, new projects getting underway, extra benefits, etc.,—you may find any other part of the magazine more suitable for this purpose.

But no matter where you position your employment advertising, your company will be listed on the "Employment Inquiry" form which appears in this section.

Although not an application for employment, it provides you with detailed information about technical personnel interested in your company. After evaluating their specialized job interests, experience and formal education —which must be included in the form before it is sent to you —you can personally contact those best qualified for the job.

When scheduling your recruitment advertisements in Space/Aeronautics, be sure the insertion order specifies where you want the advertisement to appear—"run-of-book" or in the "Employment Opportunities" section.

Planning a Strategic Move?

Many unusual opportunities are available to qualified engineers and scientists capable of assuming responsible positions with HRB-Singer. One of the country's leading R & D organizations, HRB continues to expand its research and development activities at a rate far surpassing most electronics industries. Top scientific personnel continue to make state-of-the-art advancements in the development of complete electronic systems but a constant supply of new talent is essential to the continued growth of any organization.

HRB-Singer, the acknowledged leader in the development of airborne infrared reconnaissance systems, provides extensive R & D facilities in an atmosphere conducive to professional development.

In addition to the many technical challenges, HRB provides an exceptional employee benefit package which includes Company financed graduate study at the Penn State University, free hospitalization and life insurance along with an extremely liberal vacation program.

If you are interested in learning more about career opportunities at HRB-Singer, write George H. Rimbach, Supervisor of Personnel, Dept. R-4.

HRB

HRB-SINGER, INC.

A SUBSIDIARY OF THE SINGER MANUFACTURING COMPANY

Science Park, P.O. Box 60, State College, Pa.

Check Inquiry Form on Page 145

ENGINEERS • SCIENTISTS

a technical adviser's seat at the conference table

...where the requirements of the aerospace control environment are defined—decisions implemented

This seat is reserved for MITRE, Technical Adviser to the Air Force for command and control systems.

Electronic Systems must meet the challenge to command posed by present and future weapons, aerospace vehicles and widely dispersed forces.

MITRE works with the Air Force in planning and developing these systems. The job demands application of the most advanced command and control technology.

Many technical disciplines are pursued with a scientific objectivity engendered by the corporation's nonprofit status and the clearly defined programs established bilaterally with the Air Force Electronics Systems Division.

Specifically, MITRE *engages in:*

...Advance conceptual planning
...Specification of individual system requirements
...Intersystem engineering
...Research and experimentation to generate new command and control techniques

Engineers and scientists interested in the new field of command and control technology are invited to inquire about openings in:

- Operations Research
- System Analysis
- Communications
- Econometrics
- Human Factors
- Radar Systems and Techniques
- Advanced System Design
- Air Traffic Control System Development
- Computer Technology
- Mathematics
- Antenna Design — Microwave Components

Write in confidence to: Vice President — Technical Operations

THE MITRE CORPORATION

Post Office Box 208, 30-MV — Bedford, Massachusetts

All qualified applicants will receive consideration for employment without regard to race, creed, color or national origin.

Investigating Employment Opportunities?

Want more information about employment opportunities offered by companies advertising in this issue? Then be sure to give complete data about your job interests, experience and education when filling in the "Employment Inquiry" form.

Although not an application for employment, it provides employment managers with information to evaluate your capabilities—and in turn give your request immediate consideration.

Check the "Employment Inquiry" form for details.

Check Inquiry Form on Page 145

NEW SPACE AGE FUTURES FOR

engineers

in CONNECTICUT or FLORIDA

Pratt & Whitney is expanding its operations at their *East Hartford, Connecticut Facility* and *Florida Research and Development Center* in advanced research and development projects and long-range product planning. Current programs include: the LR 115-liquid hydrogen rocket engine for Centaur and Saturn and the J58-Mach 3 turbojet engine. Advanced Research and Development programs are exploring the fringe areas of technical knowledge in magnetohydrodynamics, thermionic and thermo-electric conversion, hypersonic propulsion, fuel cells and nuclear power for military, space and industrial applications. Openings exist at all levels of experience for engineers and scientists who want to work as part of a team dedicated to maintaining Pratt & Whitney's position of leadership in the future.

ADVANCED PROJECTS AND APPLIED RESEARCH GROUPS

For new research and development projects and long-range product planning in the fields of propulsion and power systems and their applications.

- Aero Thermo Engineers - for performance and optimization studies of all types of advanced power plant and vehicle systems including air and space craft, missile aircraft, marine and industrial applications.
- Applied Science - for advanced research and development work in the fields of nuclear, chemical and direct conversion equipment. Openings exist at BS through PhD levels in Engineering or Physics.
- Nuclear Engineers - to work with advanced concepts in reactor systems and components.

ROCKET ENGINE TEST SUPERVISORS (Florida only)

Experience required in the technical and administrative direction of rocket engine test complexes. Plan, schedule, co-ordinate and supervise engineers and support personnel. Broad knowledge of test equipment, facilities design and construction, test operations and support activities required.

MECHANICAL DESIGN ENGINEERING

Engineers to engage in the mechanical design of propulsion systems, including turbojet, turbo fans, solid rockets, liquid rockets, magnetohydrodynamics, nuclear and fuel cell power applications. Must have a minimum of 5 years' related experience.

ANALYTICAL DESIGN ENGINEERING

Engineers with experience in the analysis of propulsion systems design, including the fields of advanced structures, stress analysis, vibration, compressor analysis, turbine analysis and combustion and heat transfer. Must have a minimum of 5 years' related experience.

EXPERIMENTAL ENGINEERING

BSME's or AE's with 2 - 5 years' experience to conduct and direct rocket engine and component development. Of particular interest are those who have had engine performance, fuel and control systems experience on advanced propulsion systems.

ELECTRICAL ENGINEERS

2 - 3 years' experience in electromechanical, electrohydraulic, and electro-pneumatic servo control systems; systems design, trouble-shooting, and calibration; should have good mechanical background.

TEST FACILITIES ENGINEERS (Florida only)

Facility engineers and test equipment designers with 4 - 7 years' experience in the turbojet and rocket fields.

Please submit your complete resume, including minimum salary requirements, to:

MR. P. R. SMITH, OFFICE 75
PRATT & WHITNEY AIRCRAFT
410 MAIN STREET
EAST HARTFORD 8, CONN.

—or—

MR. J. W. MORTON, OFFICE 75
PRATT & WHITNEY AIRCRAFT
WEST PALM BEACH
FLORIDA

All replies will be handled promptly and in complete confidence.

PRATT & WHITNEY AIRCRAFT

DIVISION OF UNITED AIRCRAFT CORPORATION

All qualified applicants will receive consideration for employment without regard to race, creed, color or national origin.

Check Inquiry Form on Page 145

AERO-DYNAMICIST

CAREER APPOINTMENT

The Applied Physics Laboratory of the Johns Hopkins University offers an attractive career appointment to a man with a B.S. degree in aeronautical engineering, an aerodynamics major or strong academic background in mathematics and physics. In addition, the respondent will benefit from some practical experience in the areas indicated below.

The man we seek will conduct wind tunnel tests—and analyze the data—on drag, stability, control, special flow characteristics, etc., for all of APL's missile programs. He will analyze flight test data to verify or revise wind tunnel on theoretical predictions and explain flight anomalies that may be attributable to aerodynamic behavior. He will also assist in planning flights of test vehicles to secure aerodynamic information and check out air frames.

Our modern laboratory is located an equal distance between Washington, D.C. and Baltimore—offering you a choice of country, suburban or city living.

All qualified applicants will receive consideration for employment without regard to race, creed, color or national origin.

For additional details about this position or other interesting career opportunities, direct your inquiry to: Professional Staff Appointments

The Applied Physics Laboratory
The Johns Hopkins University
8617 Georgia Avenue, Silver Spring, Md.

Check Inquiry Form on Page 145

AIRCRAFT DESIGN ENGINEERS

Inquire about new opportunities at

AIRLIFT CENTER U. S. A.

Requires engineering degree and two or more years experience in one or more of the following: Structural, avionics, controls, electrical and electronics, empennage, equipment, fuselage, hydraulic, landing gear, power plant or wing design.

ENGINEERING DRAWINGS CHECKERS—Structural

Engineering degree and previous structural design experience preferred. Must have three or more years engineering drawings checking experience.

AIRLIFT CENTER U.S.A. at Marietta is eight miles from the city limits of beautiful Atlanta. Due to its location on a plateau at a 1050 ft. altitude, residents of the Greater Atlanta-Marietta area enjoy a year-round climate unparalleled in the East. Combine work in an exciting professional environment with living in one of the finest cities in the country.

Write in confidence to: Hugh L. Gordon, Professional Employment Manager, Lockheed Aircraft Corporation, 840 West Peachtree Street, Atlanta 8, Georgia.

Lockheed / GEORGIA

All qualified applicants will receive consideration for employment without regard to race, creed, color or national origin.

Check Inquiry Form on Page 145

Investigating Employment Opportunities?

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Although not an application for employment, it provides employment managers with information to evaluate your capabilities—and in turn gives your request immediate consideration.

Check the "Employment Inquiry" form for details.

ATTENTION ALL ENGINEERS

If you are seeking new job opportunities be sure to read all employment advertisements in this issue — both in this Special Section and throughout the magazine

FLIGHT SYSTEMS ENGINEER

The leading developer and manufacturer of air data systems* has an opening for a creative BSEE with five years of experience in the design and development of electronic or electromechanical equipment.

This outstanding position requires a recent background of high level design in servomechanisms and closed loop systems, plus a knowledge of small electromechanical components such as resolvers, gyros and synchros.

In addition to the above requirements, a thorough working familiarity in solid state devices and analog computer techniques would be very helpful.

U.S. citizenship or previous secret clearance required. All qualified applicants will receive consideration for employment without regard to race, creed, color or national origin. To arrange an interview, please send complete resume to Mr. Tom Watson.

** Garrett centralized air data systems are standard equipment on many of the Free World's supersonic aircraft, including the F-104 pictured above.*

THE GARRETT CORPORATION
AiResearch Manufacturing Division
9851 So. Sepulveda Blvd., Los Angeles 45, California

Check Inquiry Form on Page 145

ROLLWAY Precision Radial Roller Bearings

——— designed for the space age

Acceleration and deceleration shocks! Multiple G forces, both radial and axial! Plus thermal variations in the extreme! Each makes new demands on design and materials. All require advanced concepts in the alloying, melting, forging, grinding, dimensioning and stress relief of high-temperature, tight-tolerance bearing metals.

Already operational in out-front aeronautical applications, new and more sophisticated Rollway Precision Radials are on the boards or undergoing R&D for top aircraft producers.

For a quick view of dynamic capacities, load ratings, limiting speeds, etc., ask for Precision Radial Catalog No. AR159. For a glimpse into potentials, let our R&D men discuss the possibilities with you. Rollway Bearing Company, Syracuse, N. Y.

COMPLETE LINE OF RADIAL AND THRUST CYLINDRICAL ROLLER BEARINGS

ROLLWAY®

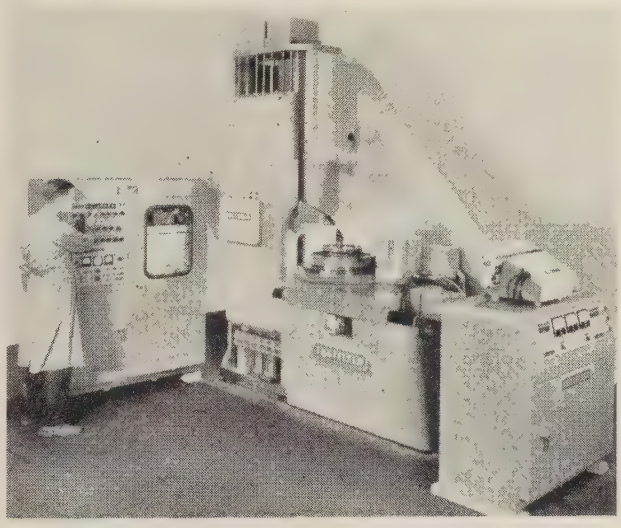
ENGINEERING OFFICES: Syracuse • Boston • Chicago • Detroit • Toronto • Pittsburgh • Cleveland • Seattle • Houston • Philadelphia • LosAngeles • SanFrancisco

No. 103 on Reader Service Card.

MATERIALS AND PRODUCTION equipment preview

For details on equipment listed in this section, write in item number on Reader Service Card

JUMBO TAPE-CONTROLLED SYSTEM MEASURES PRECISION PARTS



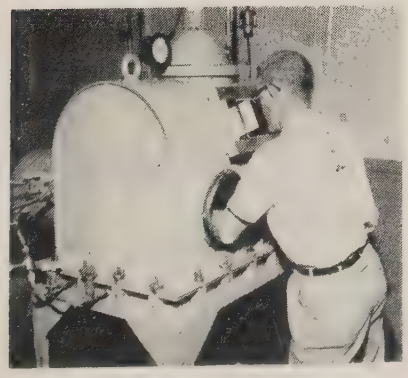
A 16-ton system that is "commanded by a roll of punched tape and can complete in two hours almost 1000 precise measurements of a critical component such as a missile nose cone," has been announced by The Sheffield Corp., Dayton 1, Ohio. It would require about a month, the company says, to make the same measurements by any other means. The jumbo gage is said to be so sensitive that it can detect a change as small as 10 millionths of an inch in the size of relatively large internal and external measurements.

The Sheffield universal 5-axis numerical tape controlled measuring machine, TC-101, can measure the inside, outside, and thickness of parts of any shape. The system simultaneously measures the inside and outside dimensions or the contour of a part, determines wall thickness, and prints the results as well as providing visual readout. It positions and measures the positions of the electronic gaging styluses at any point or angle to within $\frac{1}{10}^{-4}$ of an inch in the gaging range of 20 in. in length and height. Wall thickness is measured to an accuracy of 50 millionths of an inch.

The part to be measured rotates on the positioning table while Electrojet* sensing devices, so sensitive that their movements can be amplified electronically 10,000 times, "feel" the inner and outer surfaces, and the thickness, of the measured part. Contour and thickness data are typed automatically on the printout unit. **50**

* Registered Trademark

Vacuum Welding Chamber Features Adjoining Loading-Storage Area



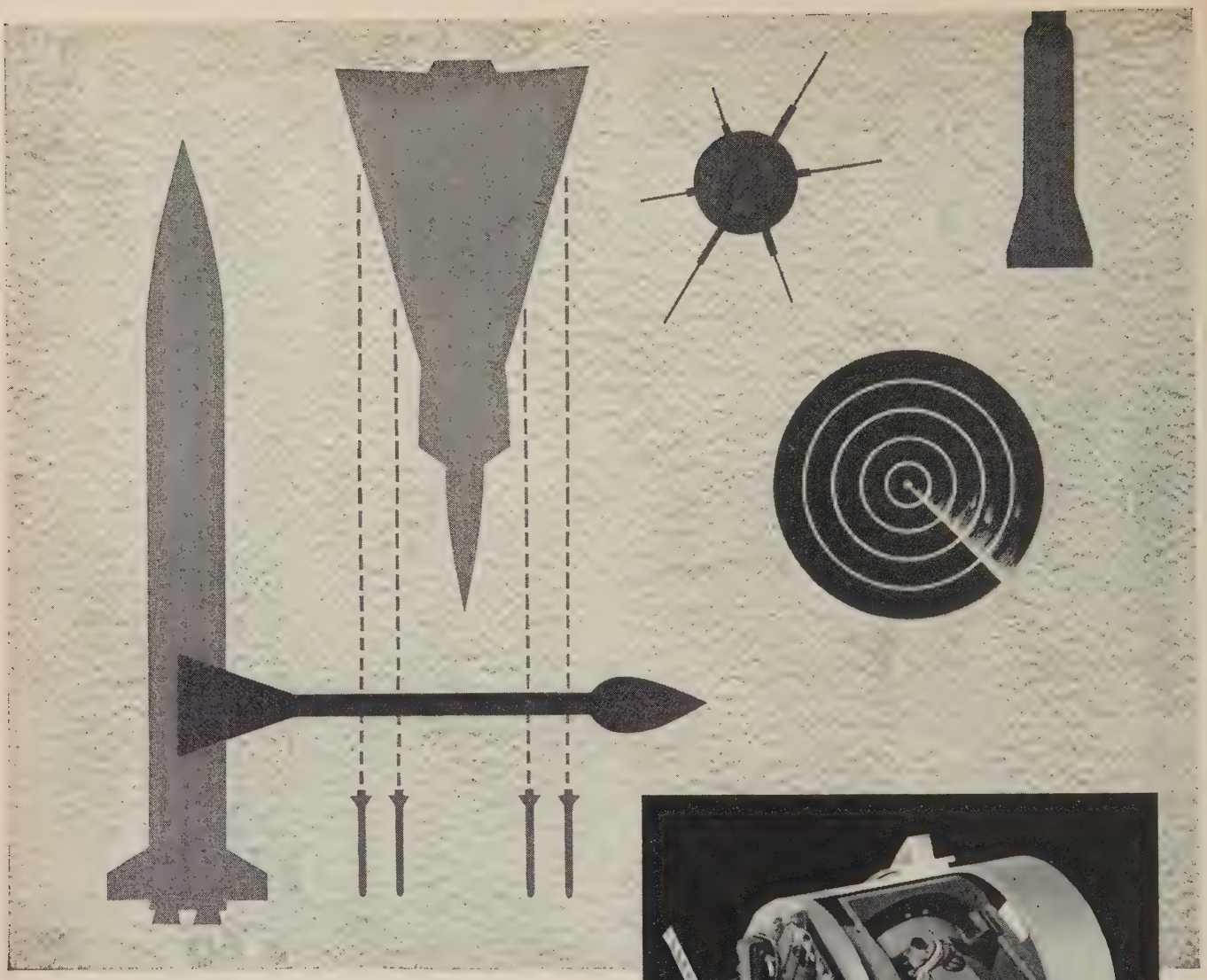
An economical vacuum welding chamber with a loading and storage compartment adjoining the welding compartment has been designed and built by the Temco Missiles & Aircraft Div., Ling-Temco Electronics Inc., P.O. Box 6191, Dallas 22, Tex.

According to the company, the loading-storage feature allows the operator to weld more than one job without decompressing the welding compartment. Once the workpieces have been loaded into the supply compartment and both compartments purged, parts may be loaded and unloaded through an access port connecting the two. By sealing the access port, the outside port to the supply area may be opened to remove or load parts, and the supply area may be purged while welding continues in the other compartment.

After each day's work, the welding compartment may be kept pressurized and purged to eliminate the purging operation the following day.

The chamber's welding compartment is 36x25x20 in. An inverted U-shaped hood of $\frac{5}{16}$-in. mild steel covers the compartment's rectangular steel base. Two long, black rubber gloves are sealed into one side of the hood, so that the operator can weld inside the compartment without contaminating its purged atmosphere.

Molybdenum and Fansteel 82, the columbium-base alloy, have been fusion-welded in the chamber, using a manual heli-arc welder with a thoriated tungsten electrode.

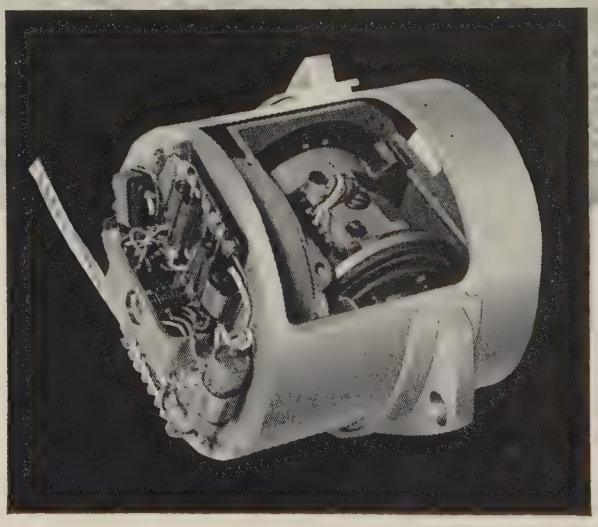


VERSATILITY IN A VERTICAL GYRO

Compact... Lightweight... Reliable... Long Life... Low Cost—The GG99 is a basic gyro, adaptable for many applications. Versatility of design makes it suitable for use in: stabilization of airborne radar, aircraft autopilots, target drone autopilots, reconnaissance drone telemetry, fire control, space probes, and short range, low-cost missiles or in any other application where angular displacement information is needed. The GG99 is also available as a directional or as a free gyro.

The precision, metal-cased, mercury accelerometers which sense vertical have extremely high reliability, resulting in long erection system life. Controlled rotor run-up gives fast initial erection without the need for amplifiers or external electronics. Size, weight and number of parts have been reduced to obtain highest reliability. Power requirements are low and no increase in erection system power is necessary at start to attain gyro vertical in a matter of seconds.

The GG99 is available with center, or end flange or base flange mount, with caging mechanisms optional. Hard or vibration isolator attachment points can be provided. Also can be modified to directional or free gyro with caging mechanisms optional. For additional information, contact your nearest Honeywell representative, or write for Data Sheet AD-270: Honeywell, Aeronautical Division, 2600 Ridgway Road, Minneapolis 40, Minnesota. *Sales and service offices in all principal cities of the world.*



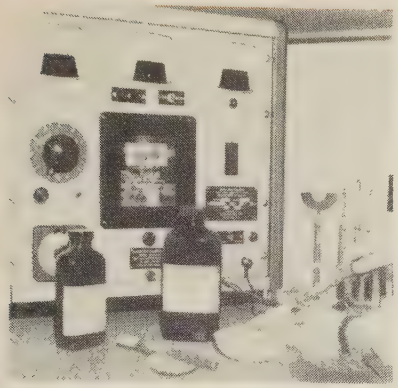
CHARACTERISTICS — GG99 is a two-axis, displacement gyro. As a vertical gyro it measures local vertical to within ⅛°. The rotor is driven at 24,000 rpm by a hysteresis synchronous motor and has an angular momentum of 2×10^6 gr.cm.^{2}/sec. It operates over a temperature range of –54°C. to 71°C. and has no altitude limitations. Withstands 50 G. shock, 10 G. vibration. A hermetic seal (with unique wire heater for quick reseal) assures meeting the thermal, shock, sand and dust, salt spray, humidity and fungus conditions of MIL E5272C.

Engineers and Scientists
Explore the professional opportunities at Honeywell

Honeywell

Military Products Group

No. 104 on Reader Service Card



Selective Process Plates Dime-Size Spots

A brand-new selective plating process is being marketed by Selectrons, Ltd., 520 Fifth Ave., New York 36, N. Y. Through use of a special power pack, plating styluses, and non-toxic, generally basic electrolytes, the process permits the deposit of metals and alloys on almost any conductive basis material.

The power packs are available in AC and DC, and are light and compact. Readings on totalizing ampere-hour meters are readily converted into exact deposit thicknesses, since each Selectron electrolyte is compounded for a known rate of deposit.

The Selectron process can plate selected areas as small as a dime without extensive masking or stopping off, and without large tanks of electrolyte. The process is claimed to be particularly suited for prototype work, where new solutions are to be tried; for production work, when large components need plating in small areas; and for maintenance and repair, because selective plating often eliminates complete dismantling.

Current is sent through the component to be plated via two leads from the rectifier. The cathode is clamped to the workpiece; the graphite anode is wrapped with cotton, and saturated with the appropriate electrolyte. As the anode is swabbed over the area to be plated, metal deposits quickly because of the high current densities. These are so high that a two-mil thickness of tin may be deposited on one square inch of basis metal in less than a minute.

Selectron "desk-top plating shops" are available for delivery within 2-3 weeks. **51**

equipment in brief

WALL THICKNESS GAGE has wide range, is fast

This nuclear wall thickness gauge is said to have an extremely wide range. It can measure from .02 to .150 in. and enables a measurement to be taken in less than 60 seconds, according to **Franklin Systems, Inc., Dept. S/A, 2734 Hillsboro Rd., W. Palm Beach, Fla.** Users do not require an Atomic Energy Commission license.

Measurement with the model 130 is made by placing an extremely thin (.03 in. maximum diameter) radiation probe internally so that soft gamma radiation travels through the wall to be measured before reading the detector heads. A 50 microcurie radium D soft gamma radiation source and scintillation counting techniques are used to perform the measurements.

No. 250 on Reader Service Card

LUBRICANT DEVELOPED for use with liquid oxygen

A lubricant has been developed for rocket propellant systems. According to the **Autolene Lubricants Co., Dept. S/A, Denver 4, Colorado,** the lubricant is completely compatible with liquid oxygen, does not react adversely when used on aluminum, and provides good protecton against wear and galling.

Known as Protex Lox-Film, the lubricant is a blend of dry powders coated with a fluorinated binder and a wetting agent. Sprayed on a surface, Lox-Film is reported to form a lubricant that does not set or dry. Also, it is not affected by extremes in temperature, says the company. The lubricating film does not detach itself from the surface under normal operation.

No. 251 on Reader Service Card

TELEMETRY BY TELE-DYNAMICS

1 and 2 -watt

Transistorized FM Transmitters

If you've a need for light—17 ounces—extremely compact—20 cu. in.—215 to 260 telemetry transmitters, specify Tele-Dynamic's Type 1053A and Type 1055A.

Providing one- or two-watt true FM output respectively, they employ dependable silicon transistors for high efficiency and offer better than 0.01% frequency stability. Type 1055A uses germanium transistors in the output stage. Each will operate reliably at any altitude and under any environment. Pressurized aluminum cases seal out the effects of altitude, humidity, salt spray, sand and dust.

These units, representative of Tele-Dynamic's latest creative effort in the complete telemetry field, are capable of being combined into various custom systems and are low in cost.

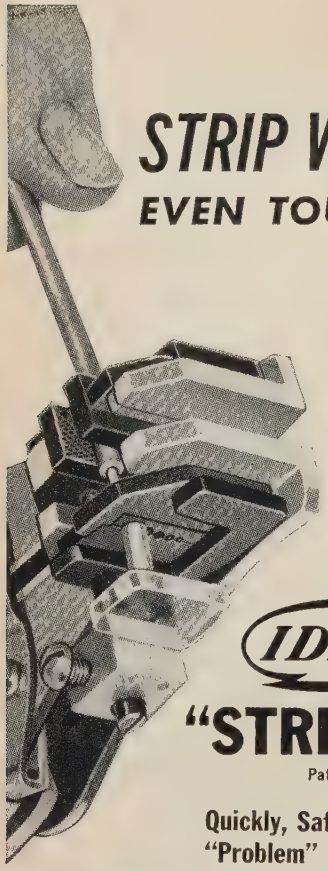
For detailed technical bulletins, call the American Bosch Arma marketing offices in Washington, Dayton or Los Angeles. Or write or call Tele-Dynamics Division, American Bosch Arma Corporation, 5000 Parkside Avenue, Philadelphia 31, Pa. Telephone TRinity 8-3000. 8412

TELE-DYNAMICS DIVISION

AMERICAN BOSCH ARMA CORPORATION

5000 Parkside Ave., Philadelphia 31, Pa.

STRIP WIRE FAST--
EVEN TOUGH TEFLON*



WITHOUT A NICK!

IDEAL CUSTOM

"STRIPMASTER"

Patented, No. 2,523,936

Quickly, Safely Removes "Problem" Insulation from Wire

Now strip the toughest insulation from any wire with just a gentle, harmless squeeze. With Ideal Custom Stripmaster, matched sets of counterbored blades—*precision drilled on watchmaker's equipment to fit wire sizes exactly* are designed to ride on cut insulation, and eliminate wire nicking and scraping. Firm grip of jaws prevents insulation damage. Wire is stripped absolutely clean up to a full 7/8".

Optional transparent wire stop quickly adjusts so that you strip off the exact amount of insulation you want every time. Perfect for fast, accurate production line stripping.

Custom Stripmasters come in three models for 10 to 14, 16 to 26, or 26 to 30 wire gauges.

SOLD THROUGH AMERICA'S LEADING DISTRIBUTORS

In Canada: Irving Smith, Ltd., Montreal

*Reg. Trade Mark of DUPONT

The Custom Stripmaster is just one of a complete line of Ideal strippers including Thermo-Strip and high-speed electrically powered models for every insulation-removal need. WRITE FOR NEW WIRE STRIPPER BROCHURE.

IDEAL INDUSTRIES, Inc.
1435-H Park Ave., Sycamore, Ill.

Please send me a copy of your new WIRE STRIPPER BROCHURE

Name_____

Company_____

Address_____

City_____ Zone_____ State_____

No. 105 on Reader Service Card

OPTICAL MATERIAL *transmits infrared*

Accessibility to the 8-13 micron atmospheric window is now possible with a new infrared transmitting material capable of withstanding both physical and chemical extremes. The introduction of Irtran-2 by **Eastman Kodak Co., Dept. S/A, Rochester 4, N. Y.**, extends the range of use for infrared transmitting materials.

The Irtran-2 material transmits more than 70 per cent of impinging energy from 2.5 to about 10 microns through 2 mm thickness. There is almost no scattering or absorption loss due to thickness of material in the 3-9 micron region, all loss coming from Fresnel reflection. The relatively high refractive index of Irtran-2 (2.25 average approx) makes the material useful for IR refractive optics.

No. 252 on Reader Service Card

LOCKNUT *is self-aligning*

This self-aligning locknut is said to develop the full rated strength of aircraft bolts even though the seating surface is as much as eight degrees out of perpendicular to the shank. According to **Standard Pressed Steel Co., Dept. S/A, Jenkintown, Pa.**, the 160,000 psi ultimate tensile strength of the nut can be counted on at all angles from 0-8 deg.

The SA16 compensating fastener is operational to 550 deg F. Nut locking torque meets M-N-25027 and wrenching strength meets NAS 1291 and MS 21042. Nuts are being made in diameter sizes No. 10 through 3/8 in., in Class 3B National Coarse and Fine thread series. They come either cadmium plated or with an approved dry film lubricant added.

No. 253 on Reader Service Card

AUTOMATIC MACHINE *formulates urethane foam*

The Model L Urethane Foam Short Run Mixer enables the operator to adjust the mixture ratio of two to as many as eight chemicals simultaneously. The mixed chemicals are automatically fed through a nozzle upon demand by the operator, and the mixture ratio can be continuously controlled by DC potentiometers.

According to the manufacturer, **The United Process Machinery Co., Dept. S/A, 1424 4th St., Santa Monica, Calif.**, there is one controller for each chemical pot which actuates small positive displacement pumps; the pump speed and hence the flow rate of each chemical into the common mixing nozzle is monitored on a meter. The machine is available with from two to eight chemical pots.

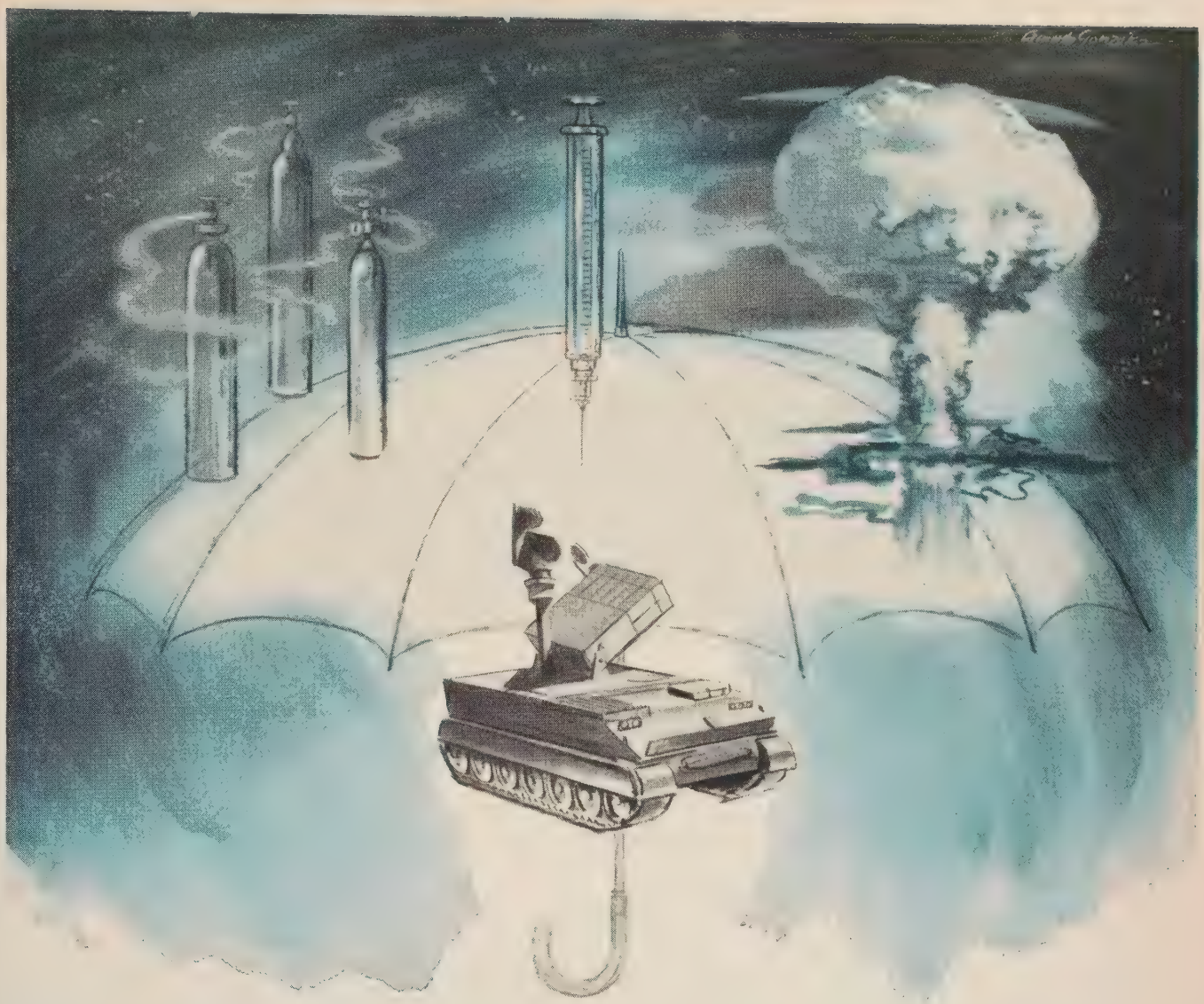
No. 254 on Reader Service Card

FLOATING NUT *is self-clinching, locking*

This floating nut is clinched by a squeeze into prepared holes, provides a rapidly assembled nut anchor in sheet metal, and also compensates for errors up to 1/32 inch in alignment of mating holes. According to **Penn Engineering & Manufacturing Corp., Dept. S/A, Doylestown, Pa.**, the fastener is suitable for sheet thicknesses of 0.040 in. and up, materials with Rockwell hardness of B-70 or less, and is available in sizes from No. 4 to 1/4 in.

Two types are available: type LAS has cadmium or cadmium chromate finished steel retainers with 18-8 stainless steel nut, passivated and with dry film lubricant; type LAC is stainless steel throughout, passivated and with dry film lubricant.

No. 255 on Reader Service Card



BATTLEFIELD PROTECTION AGAINST C-B-R ATTACK

Protecting troops under fire obviously becomes an infinitely more complex problem when that attack might possibly involve Chemical, Bacteriological or Radiological warfare; calling for special detection apparatus, filtering equipment, and decontamination systems. A team of FMC design engineers is now working on this problem, applying our company's considerable experience in chemicals and in machinery. If you have an upcoming project in this field, call in FMC at the planning stage.

For details, write Preliminary Design Engineering Dept., FMC Ordnance Division, P.O. Box 367, San Jose, Calif. Phone: CYpress 4-8124.

Putting Ideas to Work

FOOD MACHINERY AND CHEMICAL CORPORATION

Ordnance Division

1105 COLEMAN AVENUE, SAN JOSE, CALIF.

No. 106 on Reader Service Card

Half-mule, half-bird The U.S. Army's Sergeant, now in production, is artillery, and it can traverse terrain where caissons used to go rolling along. And for long, fast hops, the Sergeant can readily be airlifted. The prime contractor, Sperry Utah, wisely selected new, light gages of USS "T-1" Constructional Alloy Steel with 100,000 psi yield strength for the ground support special purpose equipment. USS "T-1" Constructional Alloy Steel is three times stronger than structural carbon steel, thus fabricated components can be made thinner and lighter with no sacrifice in strength. The entire launcher is air-transportable because it weighs only 16,000 pounds—7,000 pounds less than if built with structural

Steel "Keeps America's strength high."

Wide use of USS "T-1" Steel makes the transporter-erector-launcher 7,000 pounds lighter and completely air-transportable.

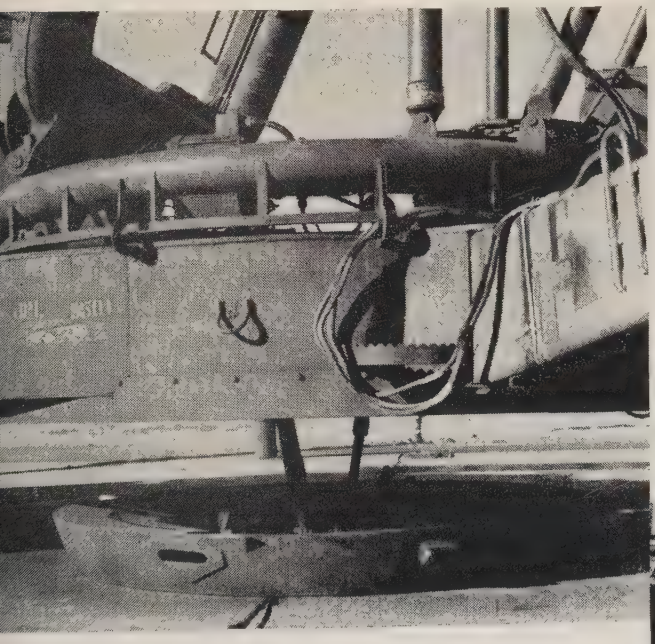
Frame components of special purpose container transport trailers are "T-1" Steel; launcher boom is also "T-1" Steel, for maximum strength and minimum weight.

All major structural components were designed at an allowable working stress of 66,700 psi.

carbon steel. When your missile support system goes on the drawing board, you can obtain applications and development assistance by consulting the one producer of all basic materials for support hardware and facilities. Whether it's carbon steel or special constructional alloy steels, electrical cable or wire rope...consult

USS United States Steel

USS and "T-1" are registered trademarks

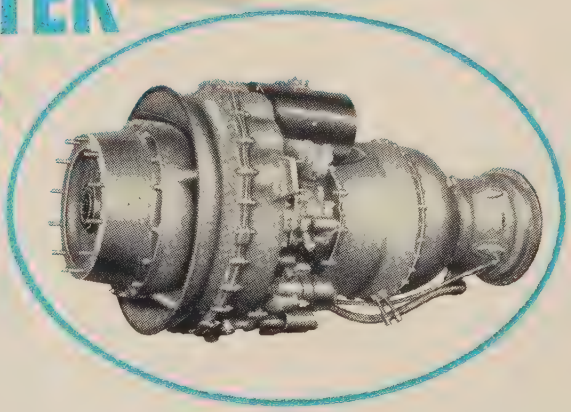


6½" diameter welded USS "T-1" Steel tubing forms the torus ring of the launching superstructure.

USS "T-1" Steel outrigger legs stabilize the unit in firing position. Also made of "T-1" Steel are the U-frame, extension arms, top and rear tension members and back beam.

The CONTINENTAL T72-T-2 HELICOPTER TURBINE

. . . BACKED BY A MILLION-HOUR RECORD OF SERVICE



The Continental T72-T-2 Helicopter Turbine has evolved directly from the highly successful J69, use-proven power plant of the Cessna T-37 Trainer and the Q-2C Target Missile. It incorporates the same annular combustor system, the same axial and centrifugal compressors, the same axial turbines and the same static structure that have withstood 40,000 test stand hours and more than 1,000,000 hours in flight. It offers high operating economy, with long life, low total installed weight, low installation performance losses, and LOW INSTALLED COST.

★ **PERFORMANCE** . . . 500 SHP with high economy (0.67 SFC) . . . multi-fuel capability (all JP, Diesel, kerosene, gasoline).

★ **RELIABILITY** . . . due to ruggedness and simplicity of design. Sturdy 2-stage compressor . . . all-steel rotating system, foreign object-tolerant . . . anti-icing inlet . . . fail-safe dual-element fuel pump . . . troublefree fuel distribution . . . emergency fuel circuit with manual controls.

★ **INSTALLATION ADVANTAGES** . . . Extreme compactness (19-inch maximum diameter; 42-inch overall length) . . . straight-out rear exhaust without obstructions or turns . . . front power output on engine center line . . . front reduction gear surrounded by cool air . . . high accessibility (all accessories mounted around waist) . . . Optional mounting—single plane, two-plane, or cantilever . . . 210 lbs. total weight.

NAVAL AVIATION 50th ANNIVERSARY 1911 1961

FOR DETAILED INFORMATION, ADDRESS:

CONTINENTAL AVIATION AND ENGINEERING CORPORATION

12700 KERCHEVAL AVENUE, DETROIT 15, MICHIGAN

SUBSIDIARY OF CONTINENTAL MOTORS CORPORATION

WESTERN SALES OFFICE: 18747 SHERMAN WAY, RESEDA, CALIFORNIA

CERAMIC FIBER for high temperatures

A high temperature insulation said to withstand continuous operating temperatures up to 2300 deg F. has been announced by **The Carborundum Co., Dept. S/A, Niagara Falls, N. Y.** Application areas range from standard furnace insulations to very complex heat shields for space age components.

The mix is of high grade alumina and silica sand heated to 3900 deg F. and poured into a molten stream the size of lead pencil. The stream is struck with a blast of air or spun into fibers of varying lengths that look like white wool.

No 256 on Reader Service Card

WELDING HEAD for electronic parts

Model 1038 is a precision welding head capable of performing single, series, or parallel welds for electronic parts, according to **Weldmatic, 380 N. Halstead, Pasadena, Calif.** The head may also be used to join fine wire, ribbon, and foils. The ball race vertical action of the dual upper electrodes is said to permit exact placement of the welds with no electrode wiping action.

The 1038 features 500 watt-second power rating, foot pedal actuation, precise controllable electrode pressure, and automatic firing. Dimensions are 9½ in. x 6½ in. x 10 in. Single, series, or parallel setups are accommodated by simple changes in the input power connections, according to Weldmatic.

No. 257 on Reader Service Card

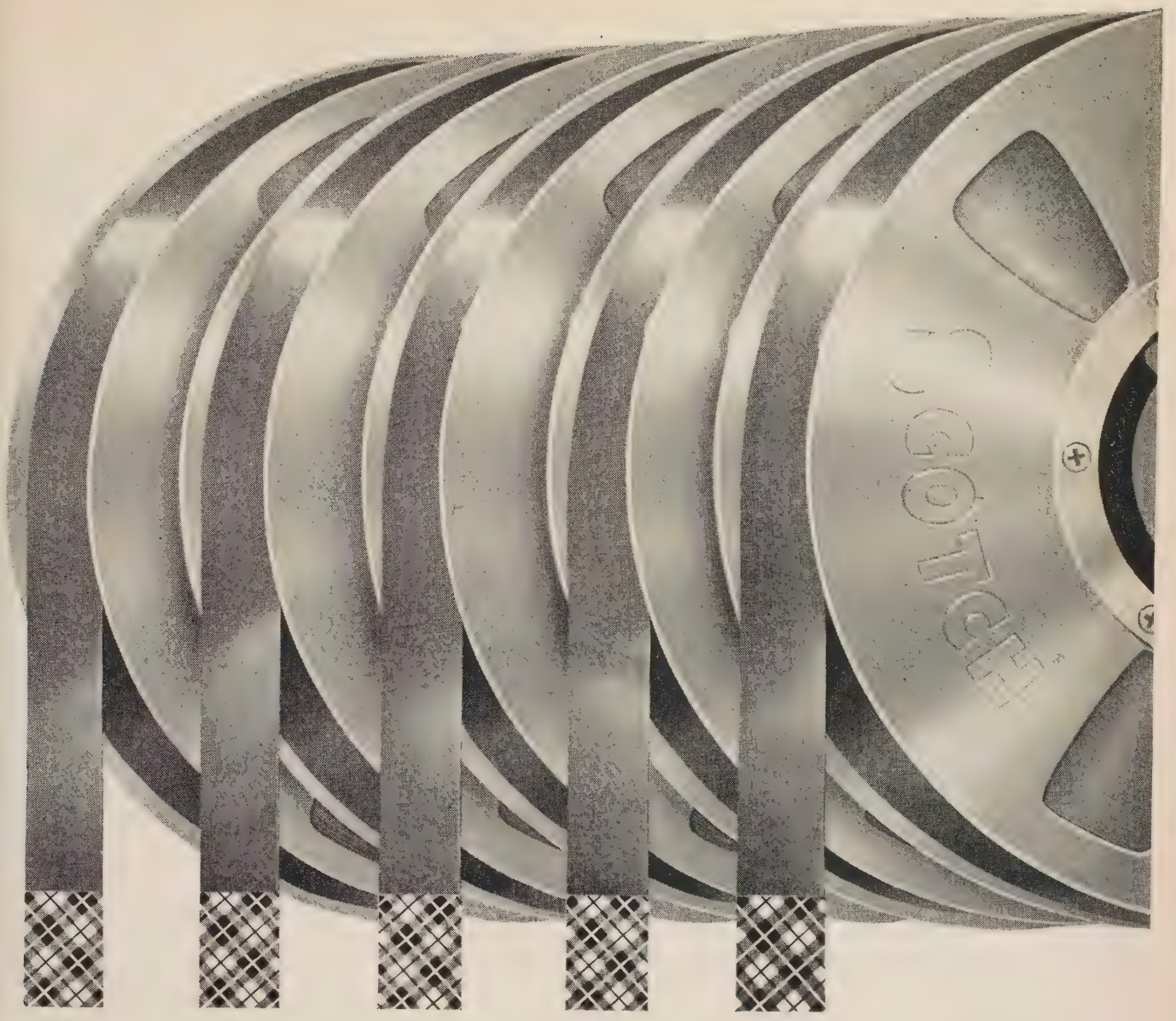
RESIN ENCAPSULANT is transparent, flexible

A silicone encapsulating material that permits visual inspection of circuits and components within potted, embedded, or encapsulated assemblies is announced by **Dow Corning Corp., Dept. S/A, Midland, Mich.** Designated as Slygard 182, the resin is applied as an almost colorless liquid after blending with its curing agent.

The material forms a transparent mass having outstanding dielectric properties, good moisture resistance and the physical attributes of flexibility and toughness, according to the manufacturing. At 150 C it cures in 15 minutes; at 65 C, in four hours; at 25 C, in three days.

No. 258 on Reader Service Card

No. 107 on Reader Service Card



SCOTCH® BRAND MAGNETIC INSTRUMENTATION TAPES OFFER A RIGHT TAPE FOR EVERY APPLICATION

Knowledgeable tape users realize that magnetic tapes are not all alike—that it takes specific constructions to meet the needs of specific applications. And they've learned to rely on "SCOTCH" BRAND to supply the one right tape for each application. Not only does "SCOTCH" BRAND offer a complete line, it offers that something extra that makes all the difference in performance—the uniformity and reliability that result from 3M's experience, technical skill, and continuing research. Make the "SCOTCH" BRAND label your guide in buying instrumentation tapes. Your 3M Representative is close at hand in all major cities—a convenient source of supply and information. For details, consult him or write Magnetic Products Division, 3M Co., St. Paul 6, Minnesota.

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The wide "SCOTCH" BRAND line provides many tapes, including these broad classifications:

SANDWICH TAPES 488 and 489—exclusive with "SCOTCH" BRAND, offering 30 times the wear of standard tapes, drastic reductions in head wear, elimination of oxide rub-off. In standard or extra-play lengths.

HIGH RESOLUTION TAPES 458 and 459—offering superior resolution in high frequencies, greater pulse density in digital recording. In standard and extra-play lengths.

HEAVY DUTY TAPES 498 and 499—offering exceptional life, good resolution, high resistance to temperature and humidity, reduction in the build-up of static charge. In standard and extra-play lengths.

HIGH OUTPUT TAPE 428—offering top output in low frequencies. Performs well even in temperature extremes.

STANDARD TAPES 403 and 408—offering the good all-round performance at low relative cost which has made them the standards of the instrumentation field.

MINNESOTA MINING AND MANUFACTURING COMPANY
...WHERE RESEARCH IS THE KEY TO TOMORROW

3M COMPANY

"SCOTCH" BRAND MAGNETIC TAPES *FOR INSTRUMENTATION*

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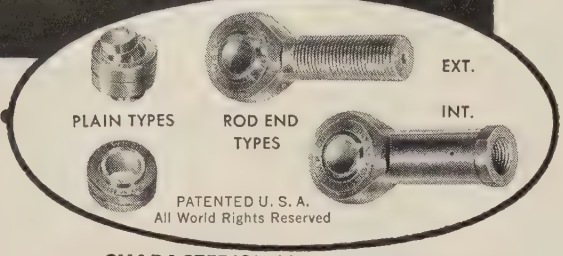
No. 108 on Reader Service Card

SOUTHWEST
"Monoball"
SELF-ALIGNING BEARINGS



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2	Chrome Alloy Steel Ball and Race	For types operating under high radial ultimate loads (3000-893,000 lbs.).
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Thousands in use. Backed by years of service life. Wide variety of Plain Types in bore sizes 3/16" to 6" Dia. Our engineers welcome an opportunity of studying individual requirements and prescribing a type or types which will serve under your demanding conditions. Southwest can design special types to fit individual specifications. Write for Engineering Manual No. 551. Address Dept. S/A 61

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No. 110 on Reader Service Card

POLYMER SEAL
works at 10,000 psi

A spring-loaded self-conforming polymer seal for use on reciprocating and low speed rotary shafts under high liquid or gas pressures has been introduced by **Del Manufacturing, Dept. S/A, 1005 S. Central Ave., Los Angeles 21, Calif.** The seal operates over a temperature range of —320 to +500 deg F and under pressures up to 10,000 psi.

Constant pressure deforms a polymer gasket in the seal to load up the shaft and produce a gas-tight seal. Since the deformation load is always towards the shaft, the gasket is self-adjusting to "creep" and wear.

No. 259 on Reader Service Card

CORE MATERIAL
aids panel design

A honeycomb core material having properties capable of improving efficiency of panel designs has been announced by **General Grid Co., Dept. S/A, 764 Alcoa Bldg., Pittsburgh 19, Pa.** The aluminum product, called Trussgrid, is said to display unusual strength and absence of contraction and expansion.

Corrugations of each foil layer form a 90 deg angle with those of its neighbor. The channels in alternate layers of foil run in the same direction, providing strength and rigidity in three planes. Nature venting characteristics are said to promote bonding with all types of adhesives, without perforating cell walls for the escape of gases.

No. 260 on Reader Service Card

TITANIUM ALLOY
has high strength

A new sintered titanium alloy with a tensile strength of 119,000 psi, ductility of six per cent elongation, and Rockwell hardness of C-23, has been announced by **Clevite Corp., Mechanical Research Div., Dept. S/A, 540 East 105 St., Cleveland 8, Ohio.** By heat treatment a strength as high as 146,000 psi can be obtained.

Clevite says the economic advantages of powder metallurgy processing can be utilized without sacrificing the high strength, light weight, corrosion resistance, and low coefficient of thermal expansion normally associated with titanium.

No. 261 on Reader Service Card

SILICONE RUBBER
resists low temperatures

This silicone rubber compound is resistant to low temperatures and can be used in molded and extruded seals, and many mechanical applications. As described by **General Electric Co., Silicone Products Dept. S/A, Waterford, N.Y.,** SE 5401U is a 40 durometer compound with the following typical properties after 24 hours at 480 deg F: hardness (shore A)—40; tensile strength—900; elongation—400 per cent; tear strength (Die B)pi—65.

The compound may be used to meet Mil-R-5847D, class I, grade 40 and AMS-3334.

No. 262 on Reader Service Card

VACUUM CHUCK
holds large components

A vacuum chucking system designed to hold missile components up to 100 in. diameter has been announced by **The Dunham Tool Co., Inc., Dept. S/A, Box 18, New Fairfield, Conn.** A vacuum pump with hold-down pressure of 12 psi enables the chuck to develop over 33,000 lb of distortion-free hold-down pressure on a 60 in. diameter part.

An automatic safety device is incorporated to prevent loss of vacuum in the event of power failure. Various models are available to fit 5 C Hardinge type lathes, J.&L. and EX-CELL-O boring machines, Bullard VTLs, and Blanchard grinders.

No. 263 on Reader Service Card

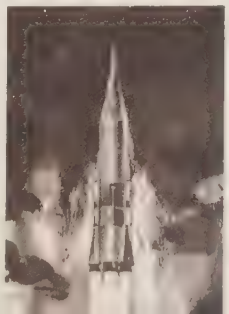
Check Inquiry Form on Page 145

Engineers and scientists at General Dynamics|Astronautics enjoy not only the immeasurable rewards of participating in the development of this nation's most advanced space systems, but the added bonus of living and raising their families in resort-like San Diego, California. San Diego's climate is near-perfect, and its ideal location permits almost any sort of family recreation the year around. Indeed, on the first day of summer last year, the temperature was 78 degrees; on the first day of winter, 76. Schools are excellent and uncrowded; cultural attractions abundant; advanced educational facilities are constantly being expanded.

If you are an experienced engineer or scientist, just a cut above the average, we'd like to tell you more about our company, our community, and how they might fit into your future. You'll find more information on the back of this page, and a convenient inquiry card which will receive immediate and confidential attention. Why not mail it today? No obligation, of course.

If the inquiry card has been removed, or if you wish to furnish or request more detailed information, please write to Mr. R. M. Smith, Industrial Relations Administrator-Engineering, Mail Zone 130-90, General Dynamics|Astronautics, 5671 Kearny Villa Road, San Diego 12, California. (If you live in the New York area, please contact Mr. T. Cozine, manager of our New York placement office, CIrcle 5-5034.)

GENERAL DYNAMICS



ASTRONAUTICS

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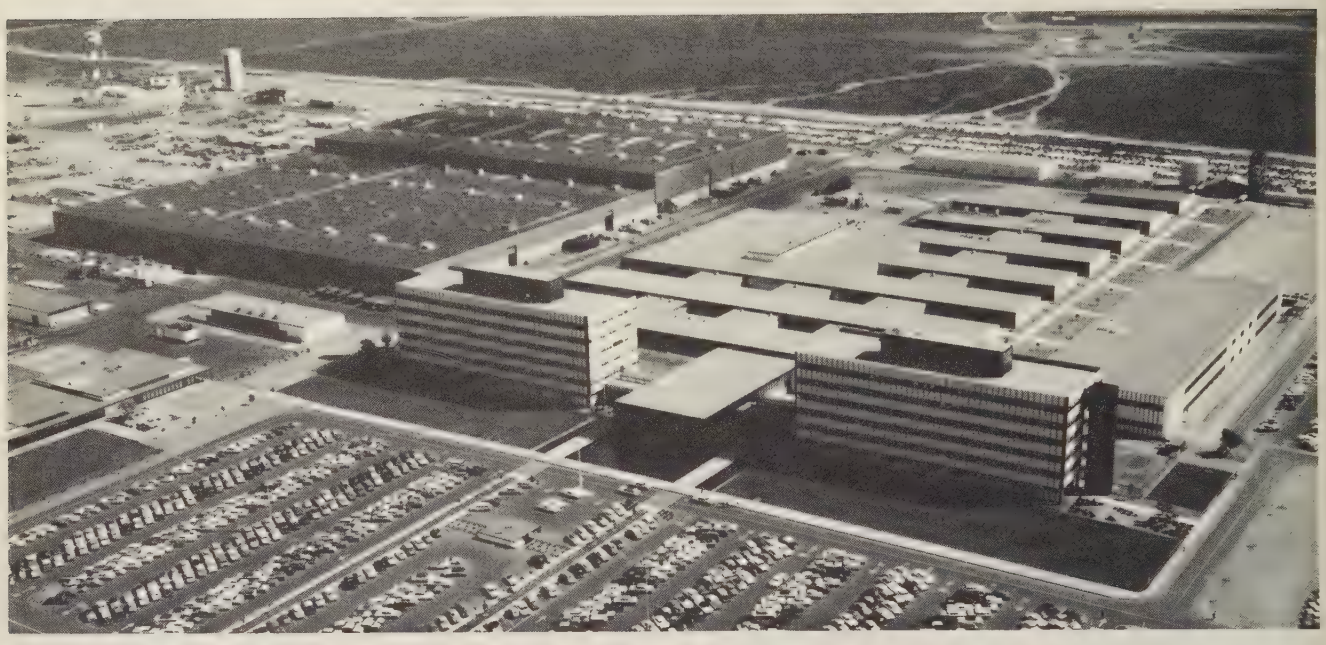
ENGINEERS AND SCIENTISTS



General Dynamics|Astronautics is located in San Diego, California, the third fastest growing community in the United States. It is situated 10 miles north of the Mexican border and a little over 100 miles south of Los Angeles.

Immediate openings exist in the following areas:

SCIENTISTS & ANALYTICAL ENGINEERS with Ph.D. or Sc. D for electronics and physical research; computer analysis and application; and instrumentation development.

ELECTRONIC DESIGN & TEST: communication systems and data transmission design; logical circuitry; automatic control systems; and electronic packaging. BSEE plus appropriate experience required.

MECHANICAL DESIGN: BSME or AE for pneumatics, hydraulics, and fluid systems design and test. Also missile GSE and missile structures designers.

RELIABILITY ENGINEERING: San Diego openings exist for experienced engineers with applied higher mathematics education, preferably in statistics; higher degrees preferred. Circuit analysis with transistor and diode experience is also desirable.

ENGINEERING WRITERS with 2 years college and 3 years experience in preparation of TCTO's; Operations, Maintenance, and Overhaul manuals.

SYSTEMS ENGINEERING: BS degree required, advanced degree desired, in engineering or related field. 2-5 years experience, including missile or similar background in testing, methods of operation, systems analysis, and evaluation. Assignments will include establishment of test requirements, determination of factory tolerance structures, and evaluation of field testing.

GUIDANCE SYSTEM ANALYSTS to define the optimum characteristics, philosophy, and mode of operation of sophisticated guidance systems of extreme accuracy. A Ph.D degree plus experience in guidance systems and missile simulation is desired, but more extensive experience in related fields will be favorably considered.

PRE-DESIGN ENGINEERS with experience in proposal preparation and system design of guidance and tracking systems.

If you desire to become part of this great team, we urge your prompt inquiry on the attached Engineering Placement Inquiry.

Technical openings also exist in other specialties. Write Mr. R. M. Smith, Industrial Relations Administrator-Engineering, Dept. 130-90, General Dynamics|Astronautics, 5671 Kearny Villa Road, San Diego 12, California. (If you live in the New York area, please contact Mr. T. Cozine, manager of our New York placement office, CIrcle 5-5034.)

ALL QUALIFIED APPLICANTS WILL RECEIVE CONSIDERATION FOR EMPLOYMENT WITHOUT REGARD TO RACE, CREED, COLOR, OR NATIONAL ORIGIN.

GENERAL DYNAMICS

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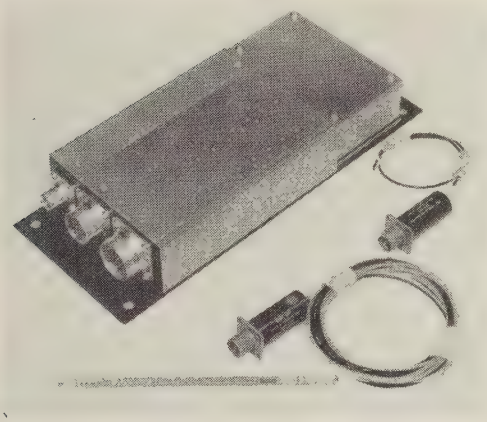
PROPULSION AND ACCESSORY equipment preview

For details on equipment listed in this section, write in item number on Reader Service Card

NINE-CHANNEL THERMOCOUPLE COMPENSATOR SYSTEM



Availability of a nine-channel thermocouple compensator system accurate to within six degrees over an operating range of 32-165 deg F has been announced by Gulton Industries, Inc., Engineered Magnetics Div., 13041 Cerise Ave., Hawthorne, Calif.

The complete temperature compensation system is composed of 19 separate units, nine zone boxes, one zone box adaptor module (containing nine channel isolated power supplies), and nine bridge circuit cards assembled into the module.

Each channel is interchangeable with any other using a resistance thermometer as one leg of a bridge circuit. The bridge circuit produces an EMF equal and opposite to that generated in the zone box, due to ambient temperature change at the junctions in the box. This EMF provides the temperature compensation.

Bridge excitations are supplied by individual power supply units for each channel; these consist of transistorized oscillator, rectifier and filter circuits.

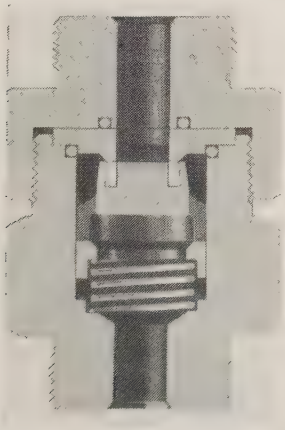
The unit is $9\frac{5}{16}$x4x$1\frac{1}{2}$ in. and weighs four pounds. **54**

Microminiature Accelerometer For Adhesion Mounting

The Model 2226 microminiature accelerometer weighs only 2.75 gm, is $\frac{3}{8}$ in. hex and $2\frac{1}{64}$ in. high, including connector. The design provides relatively high sensitivity and capacity, and incorporates mechanical isolation from cable stresses, according to the Endevco Corp., 161 E. California Blvd., Pasadena, Calif.

Voltage sensitivity with 180 pf external capacity is 5.0 pk-mv/pk-g nominal; resonance frequency is 25 kc nominal; cross axis sensitivity is five per cent max; temperature range is −65 to +350 deg F, with 15 per cent or less nominal sensitivity deviation within this range.

Endevco says that the transducer adds a new dimension to the dynamic testing of small components and light specimens whose characteristics would be affected by the mass of standard transducers. **53**



O-Seal Valves Leakproof at 6000 psi Helium

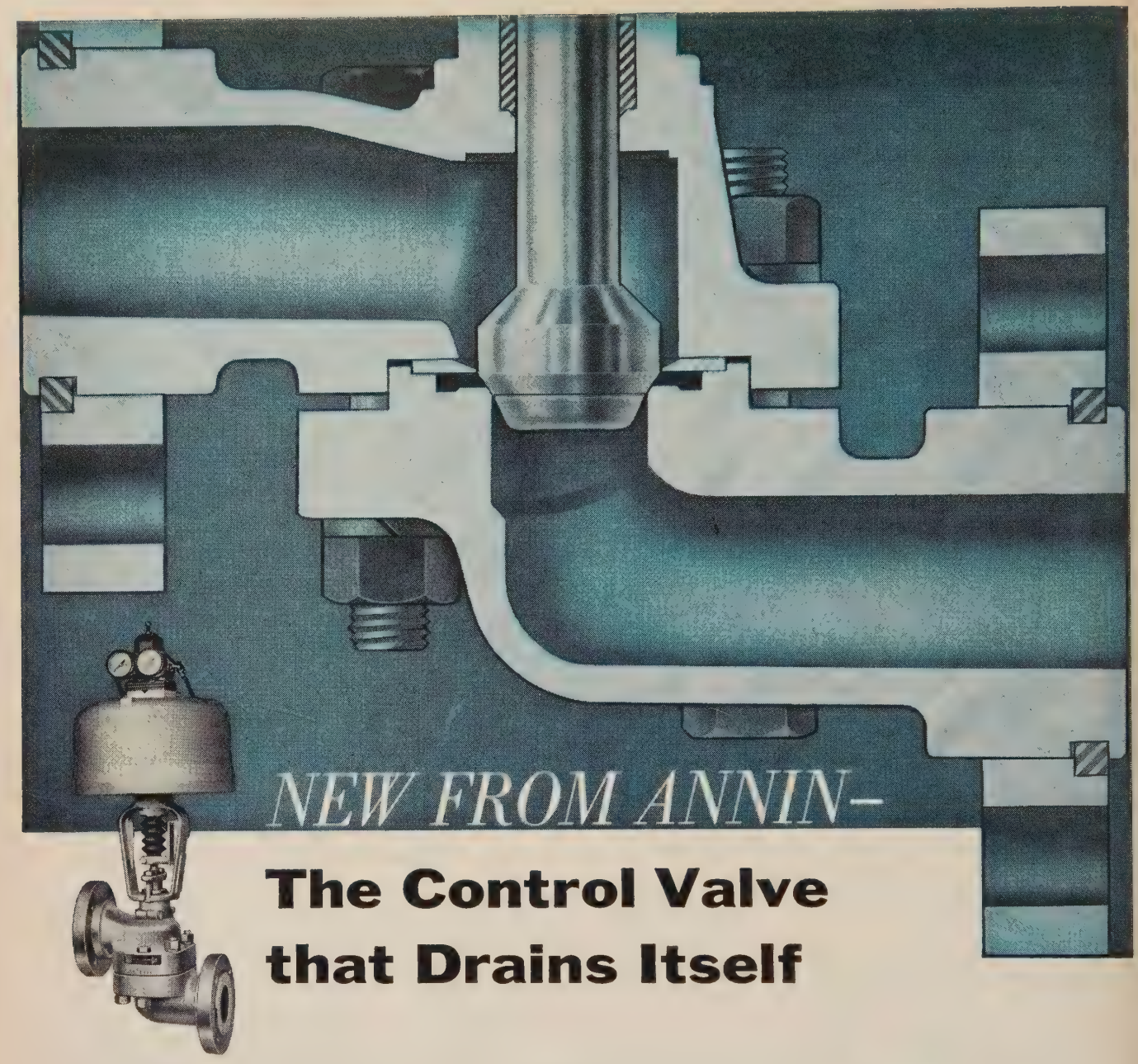
Surge and reverse flow are effectively eliminated in high-pressure liquid or gas systems with a new line of silent check valves, says the Combination Pump Valve Co., 848 Preston St., Philadelphia 4, Pa.

The O-seal valves combine a resilient seating principle with the engineered pressure of spring closure. The company says they assure positive, leakproof shut-off at up to 6000-psi and from −20 to 275 deg F, without the problems of galling in metal-to-metal seated valves.

CPV O-seal silent check valves for 6,000 psi service are produced in ¼-in. to 2-in. sizes, in in-line and globe types.

The removable bonnet in the globe type permits full internal access without breaking the line, according to the company. **65**

Check Inquiry Form on Page 145

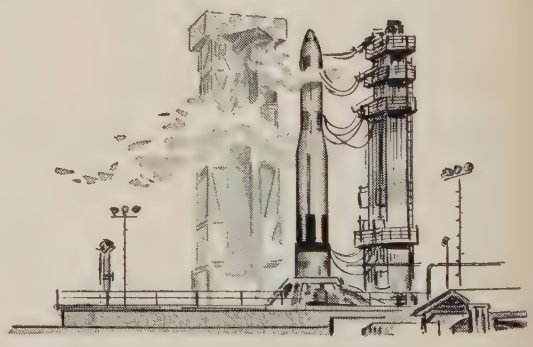


NEW FROM ANNIN—

The Control Valve that Drains Itself

ANNIN'S MODEL 1900 SELF-DRAINING CONTROL VALVE is designed to completely drain the line and valve body of corrosive fluids, slurries, and other flowing media which contaminate or tend to set up and harden in the system. Body and trim are designed so that all surfaces slope downstream, making the valve completely self-draining when installed in either the horizontal or vertical position. All body parts are interchangeable with other Annin models, allowing an option of globe, angle or three-way body patterns. Model 1900 is designed to accept all standard actuators—Pneumatic Domotor, Electro-Pneumatic, Electro-Hydraulic, Cylinder or Manual.

Send for latest technical information.



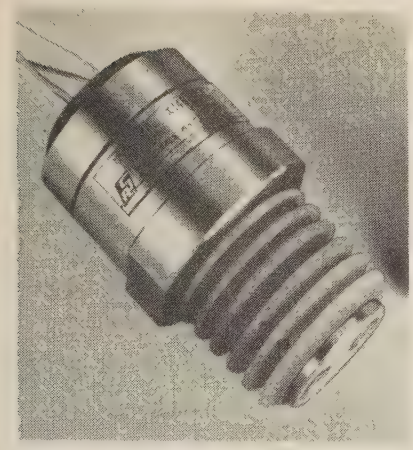
Model 1900, already proven in the use of UMDH (unsymmetrical dimethyl hydrazene), fills critical needs in the missile industry at launching and test facilities as well as fuel processing plants, where self-draining lines are required in the handling of high energy exotic rocket fuels.

Annin VALVES

THE ANNIN COMPANY
1040 South Vail Avenue,
Montebello, California

No. 111 on Reader Service Card

Miniature Servo Valve for All Hydraulic Fluids



Its new miniaturized 0-2-gpm electrohydraulic servo valve is compatible with all known hydraulic fluids, says Sanders Associates, In., 95 Canal St., Nashua, N. H. Weighing only two ounces, 2⅛ in. long and 1 1/16 in. in diameter, the "Mini*-valve" is based on a patented in-line force feedback system, pressure-balanced construction, and single-nozzle design to provide high reliability and a proportional flow-vs-input signal at low cost.

Clogging in the Mini-valve is greatly reduced, thanks to the the large, single nozzle. Particles of 200-micron size pass through the large orifice. Triggered by a weak pulse, the built-in force motor moves the in-line system to control the flow of the hydraulic fluid.

Plug-in mounting speeds up the installation and removal of the Mini-valve. The valve is inserted into a prepared bore and the screw-down collar ring is hand-tightened. Pressure-balanced construction and flexible nylon seals insure extremely low leakage. **59**

* Registered Trademark

equipment in brief

STATIC DC POWER SUPPLY is ruggedized

Model 3078 static dc power supply is now available in quantity, for conversion of 115-volt, 60-cps ac to 28-volt dc. According to **Varo Mfg. Co., Inc., Dept. S/A, 2201 Walnut St., Garland, Tex.**, this ruggedized unit is designed for continuous maintenance-free operation in missile checkout systems, fire control systems, computers, and general instrumentation.

The 14-lb, hermetically sealed unit has a reported life of 2000 hours minimum. Vibration specifications are 3 g from 12 to 60 cps; temperature range is —35 to ±125 deg F.

No. 264 on Reader Service Card

TINY TOGGLE SWITCH is 3-position type

This 3-position toggle switch's dimensions are .78 in. x .656 in. x 1.356 in. The model B-T1-3P is supplied with a keying tab .025 in. thick. The terminals are shielded by flexible insulation, according to **Milli-Switch Corp., Dept. S/A, Indianapolis 6, Ind.** Electrical rating is 5.0 amps at 120/-240 v ac; 3 amps at 30 v dc inductive at sea level, and 4 amps at 30 v dc resistive at sea level.

The switch is also available with rating of 10 amps at 30 v dc resistive at sea level; 8 amps at 30 v dc inductive at sea level; 10 amps at 125 v ac, and 5 amps at 240 v ac.

No. 265 on Reader Service Card

CYCLING TIMER controls up to 20 circuits

This type 540 cycling timer provides timed-sequence control of up to 20 independent load circuits. It allows the user to choose any of hundreds of different cycle speeds from 1 second to 11 days, says **Cramer Controls Corp., Dept. S/A, Centerbrook, Conn.** On and off points are independently adjustable for each circuit from 2 per cent to 98 per cent of full cycle time.

Accuracy is within ±½ of 1 per cent of full cycle time at operating points of each circuit. Motors are available for operation on all standard voltages at 50 to 60 cps, 115 volts at 400 cps, and 6 to 28 volts dc.

No. 266 on Reader Service Card

SAFETY by HAWS

HAWS SAFETY FOUNTAINS

Wash harmful fuels and chemicals from eyes and facial areas, instantly! Prevent discomfort and serious injury. Units may be wall or pedestal mounted; with hand or foot operated quick-opening valves.

7900 Series—Maximum coverage eye/face-wash. 6 spray outlets in extra large stainless steel bowl set up soft, drenching mist for positive first aid. Large hand valve.

7100 Series—Eye-wash sends pressure-controlled streams from chrome plated brass heads. Acid-resisting enameled iron bowl.

7700 Series—Eye/face-wash simultaneously sprays water from perforated copper ring and fountain heads. Stainless steel bowl.

HAWS SAFETY SHOWERS

Instantly flood the body with torrents of rushing water to wash away injurious contaminants. Your choice of single head or multiple nozzle showers; available with hand or foot valves.

Model 8590—Multiple Nozzle Shower instantly drenches victim from all angles. Large hand valve.

WRITE FOR HAWS DETAILED SAFETY CATALOG TODAY!

HAWS SAFETY EQUIPMENT

a product of
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Export Dept.: 19 Columbus Avenue
San Francisco 11, California, U.S.A

No. 112 on Reader Service Card

NOT THE SIZE OF THE JOB

but the demand for positioning accuracy determines the need for

BEAVER BALL SCREWS

Raytheon uses this Beaver Ball Screw in the "Hustler" search radar to actuate a delicate and extremely precise instrument control — everything else is classified, except that you can hold it between two fingers!

One of the largest ball screws ever built. This 40 foot Beaver Ball Screw positions the carriage of a giant steel mill roll lathe designed by the McIntosh-Hemphill Div. of E. W. Bliss. Chief advantages were minimized break-away friction and reduced power.

Our engineers will be glad to work with you in determining if ball screw actuation belongs in your product as opposed to hydraulics or pneumatics. Call on us.

Largest manufacturers of precision ball screws

Beaver Precision Products INC.

CLAWSON, MICH.

BALLISTIC DELAY INITIATOR uses .38 cartridge

This ballistic delay initiator, which was developed for the seat ejection system of the T2J trainer is fired by a gas pressure input of 400 to 500 psig. The 1½-oz unit, developed by the **Propellex Chemical Div., Chromalloy Corp., Dept. S/A, P.O. Box 187A, Edwardsville, Ill.**, generates a pressure of 2000 psig in a closed volume of 0.3 cu in., after a time delay of one-half second.

Chromalloy says that the special .38 caliber cartridge used in the device can be modified for various delays and/or pressure outputs.

No. 267 on Reader Service Card

SERVO AMPLIFIER has small volume

A miniature servo amplifier, with a volume of less than one cu in. has been developed for use in gimbals, gyros, platforms, and compass systems.

Available from **Lear, Inc., Dept. S/A, Box 688, Grand Rapids, Mich.**, the amplifier features a choice of phase shift characteristics, externally adjustable gain, and low output impedance with respect to load impedance. The Lear servo amplifier has evinced stability and reliability over a wide environmental range. The unit is protected from shock and vibration by heavy oil sealed within its case, and can withstand 10 g up to 500 cycles. Nominal gain of 300 may be reduced by adding an external resistor in series with the input. Normal input impedance is 5000 ohms, but at low input impedances, a gain of up to 1500 is possible.

No. 268 on Reader Service Card

INERTIA SWITCH has one moving part

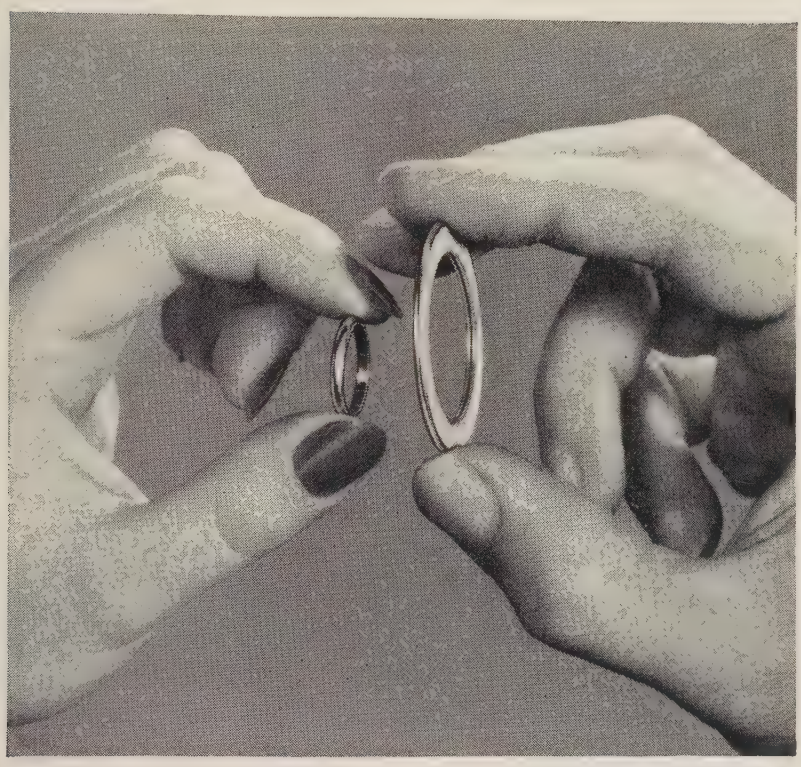
Inertia switch model 6UO-115 is reported to be accurately pre-set to respond to acceleration forces of 1 to 25 g, ±5 per cent of setting. The switch is designed with only one moving part, a precision ground steel ball, held against a solid base by a uniform magnetic field. When the opposing force of acceleration exceeds the magnetic field, the ball moves to close an electrical contact.

According to **Inertia Switch, Inc., Dept. S/A, 311 W. 43 St., New York 36, N. Y.**, the switch meets all requirements of MIL-E-5272. Operating temperature range is between -65 and +200 deg F. Miniature switches of this type are said to be applicable for control or limiting use, when actuated by acceleration, deceleration, impact, or shock. Response time of switch is 0.015 sec; electrical rating is 2 amps at 28 volts DC.

No. 269 on Reader Service Card

No. 113 on Reader Service Card

GASKETS
in Design Engineering



New, ultra-thin Garlock GUARDIAN* Gaskets solve the problem of high-temperature, limited-space sealing on missile and aircraft exhaust systems, turbines, other equipment.

At last—a spiral-wound gasket no thicker than a wedding ring! Ideal for limited space or light flange applications, this new Garlock GUARDIAN Spiral-Wound Gasket is available in thicknesses as thin as 1/16" in gaskets up to 6" I.D., maximum flange width 3/8".

Controlled density affords more positive seal. During manufacture of the new "wedding ring" GUARDIAN Gasket, the proper selected thickness of filler material and preformed metal, the number of laminations of filler and metal, and the correct tension of filler and metal while being formed into a gasket are the factors engineered to achieve proper gasket density. By controlling and varying these factors, Garlock is able to match the density to the pressure range. This built-in quality is constantly checked by a Baldwin-Lima-Hamilton compression-testing machine, thereby assuring perfect sealing regardless of different pressures and different bolt-load requirements.

High-temperature, high-strength construction. This new Garlock "wedding ring" GUARDIAN Gasket operates effectively at temperatures as high as +1900°F and pressures to 2500 p.s.i. or more. It is an excellent gasket where recycling temperatures are encountered. In the 700°F to 1200°F range, Garlock uses a compressed asbestos filler with stainless steel plies; in the 1200°F to 1900°F range, a ceramic filler is used with several different types of metal plies, depending on customer preference. The ceramic is non-flammable, completely inorganic, and an outstanding chemical insulator. It resists mold, mildew, and aging, thereby allowing indefinite shelf life.

Where service is severe and space at a premium, use new Garlock "wedding ring" GUARDIAN Gaskets. They may be the answer to your sealing problems. Find out more from your Garlock representative. Call him at the nearest of the 26 Garlock sales offices and warehouses throughout the U. S. and Canada. Or write Garlock Inc., Palmyra, N. Y.

GARLOCK

Canadian Div.: Garlock of Canada Ltd.

Plastics Div.: United States Gasket Co.

Order from the Garlock 2,000... two thousand different styles of Packings, Gaskets, Seals, Molded and Extruded Rubber, Plastic Products.

*Registered Trademark

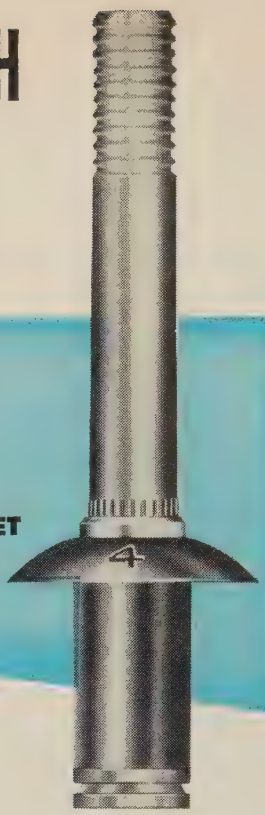
No. 114 on Reader Service Card

SOLID RIVET STRENGTH WITH BLIND RIVETS

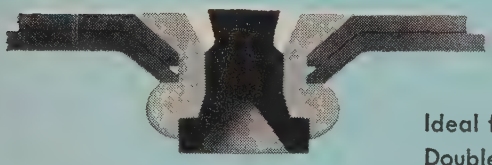
CHERRYLOCK RIVETS for Your Difficult Solid Rivet Applications

BULBED CHERRYLOCK

ONLY THE BULBED CHERRYLOCK RIVET GIVES YOU ALL THESE ADVANTAGES



Mechanically Locked Stem • Flush Fracture (No Stem Trimming) • Positive Clamp-Up • Full Grip Range • Complete Hole Fill • Minimum Blind Side Clearance • Positive Visual Inspection (Grip Length Marked on Head)



Ideal for Thin Sheet and Double-Dimple Applications—extremely large blind head

The Bulbed Cherrylock* offers a blind rivet that installs and performs like a solid rivet. Bulbed Cherrylock Rivets will qualify where you are now using solid rivets, offering higher joint strength with greatly increased joint reliability under critical loading conditions—fatigue, shake and sonic vibration.

Now Cherrylock rivets give you a blind rivet that can be used in expensive forgings as well as for joining and attaching sheets and components.

For technical data on Cherrylock Rivets, write Cherry Rivet Division, Townsend Company, Box 2157P, Santa Ana, California.

* Patent Pending

CHERRY RIVET DIVISION

SANTA ANA, CALIFORNIA

Townsend Company

ESTABLISHED 1816 • BEAVER FALLS, PA.

In Canada: Parmenter & Bulloch Manufacturing Company, Limited, Gananoque, Ontario

SERVO MOTOR is precise

A size 11 precision high temperature inertially damped servo motor is now available for high speed and high gain servo systems. The inertial damping eliminates the need for a generator amplifier.

This type 5752-30 motor is manufactured by the **Avionic Div., John Oster Manufacturing Co., Dept. S/A, Racine, Wisc.** No load speed is 5800 rpm, torque at stall is 0.60 oz-in., rated voltage is 115 volts rms, 400 cps for fixed phase and 70 volts for control phase, flywheel magnet inertia is 2.0 gm cm sq, and flywheel magnet damping factor is 80 dyne cm/rad/sec. Corner frequencies are 2.3 cps for F1, 6.4 for F2, and 23.3 for F3.

No. 270 on Reader Service Card

POWER SUPPLY yields 50 volts at 500 ma

This power package is capable of 25 watts, 50 volts at 500 ma and measures 2.5 in. by 3.5 in. by 5 in. The regulated power supply is held to 0.001 volt under all load conditions, says **Valor Instruments, Inc., Dept. S/A, 13214 Crenshaw Blvd., Gardena, Calif.** The model AMSF-50-5 uses a combination of an extremely stable reference, high-gain differential amplifier and a series regulator.

The module is plugged into circuits like other components, and delivers a reliable, stable source of dc power for ground support equipment, computer systems, transistor powering, test equipment, automation control and similar applications.

No. 271 on Reader Service Card

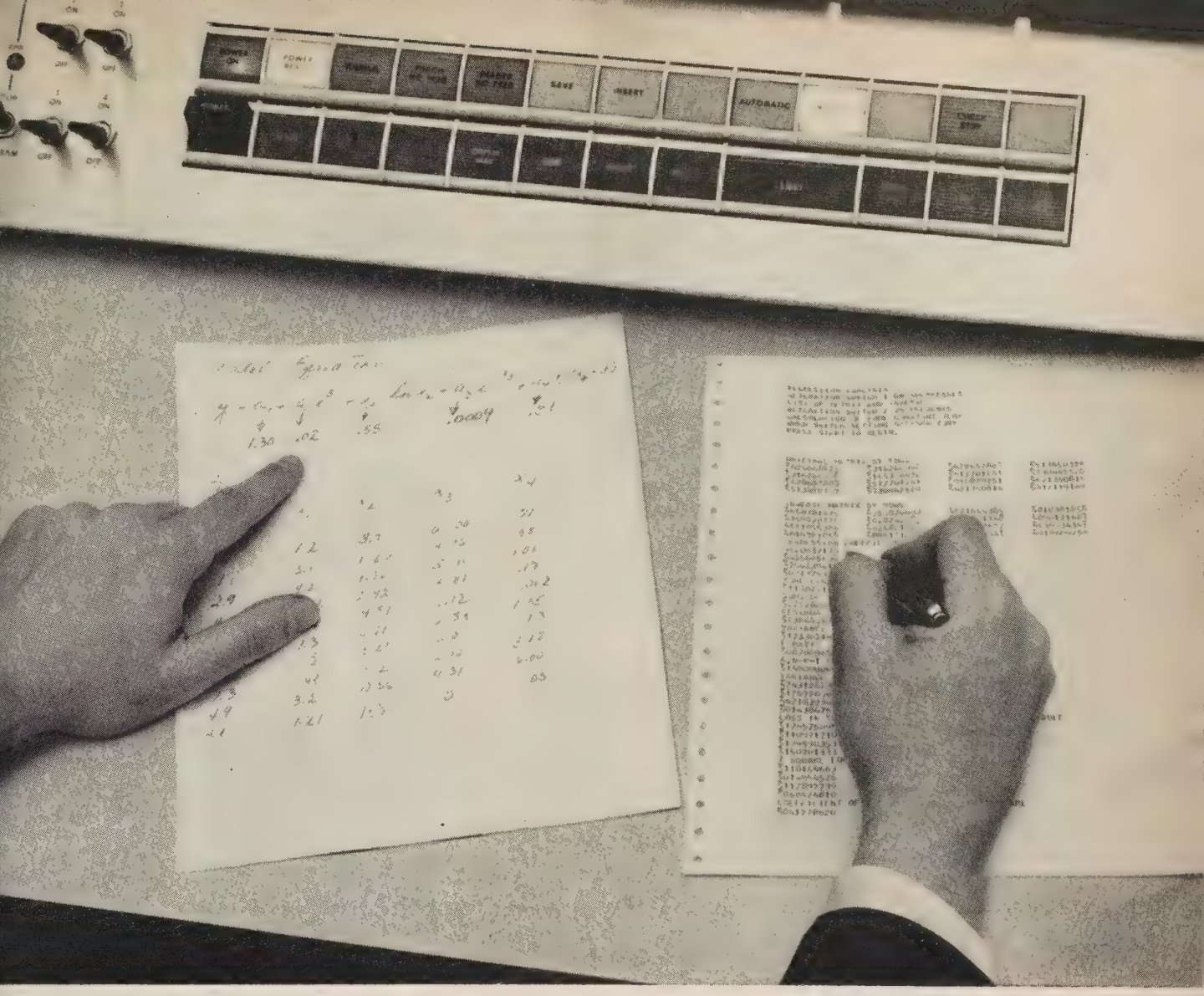
ARMING SWITCH for drones and missiles

This arming switch was designed to prevent transients, surges, and spikes in the electric power circuits from energizing warhead circuits during launch. Model El-1091 switch can be used for maximum velocity sensing control and for constant speed control, both with or without time delay, says **George Harmon Co., Inc., Dept. S/A, 18141 Napa St., Northridge, Calif.** It is reported suited for all types of inertial programming.

The force required to close the switch can be preset at the factory to vary from 1 to 20 g, within 0.5 g. The time delay can also be preset. The switch weighs less than ¾ lb, and it has a resistive load of 3½ amps maximum.

No. 272 on Reader Service Card

No. 115 on Reader Service Card



Want to find the coefficients? It's easy with the new Regression Analysis program for the IBM 1620

Here's another program offered free-of-charge to users of the IBM 1620 Data Processing System. It gives you the kind of results you might expect only from a much more expensive computer. But users of the 1620 know that its low rental cost is deceptive. The 1620 packs *more computing power per cubic inch* than any other computer in its size range.

The Regression Analysis program is a good example. Suppose you want a fit for production purposes. If you employ more than two variables you probably have difficulty visualizing the representation of your data. If linearity is not the case, you must often guess blindly at a polynomial of high degree, accept or reject the fit with something approaching a sixth sense, and either try again or settle for the results you have.

The new Regression Analysis program lets you handle expressions containing up to *24 variables*. If you have the even more complicated task of handling many dependent variables, the program will generate regression coefficients with a maximum number of dependent variables not exceeding one-half the number of independent variables.

This program will also fit non-linear functions and hyper-surfaces. Compare this performance with that of any other computer in the 1620's price range.

A basic 1620 installation rents for just $1600 per month. For details, contact your local IBM Representative.

IBM's 1620 is a compact desk-size computer.

IBM®
DATA PROCESSING

No. 16 on Reader Service Card

AUXILIARY POWER FOR MINUTEMAN'S THREE STAGES

The U. S. Air Force's Minuteman, first of the solid propellant powered ICBM's, introduces numerous design and operational features unavailable in its first generation counterparts. End result is a smaller, lighter, less complex and lower cost missile.

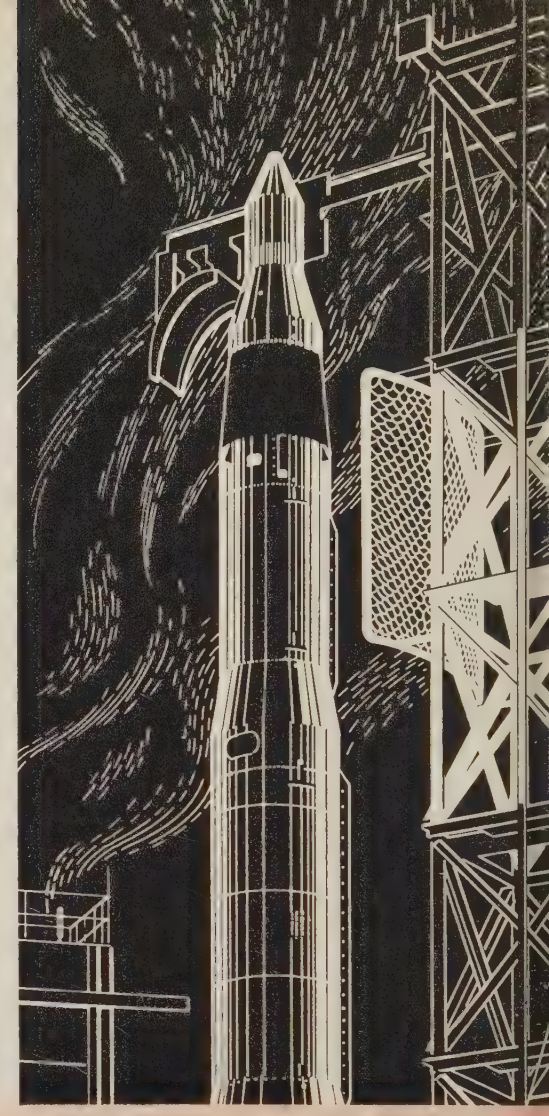
COMPACT DESIGN—Typical of these advances is the highly integrated APU design developed for all three missile stages by Vickers under contract to Autonetics, a division of North American Aviation, Inc. A significant saving in package weight and envelope is provided by immersing the hydraulic pump completely within its self pressurizing reservoir.

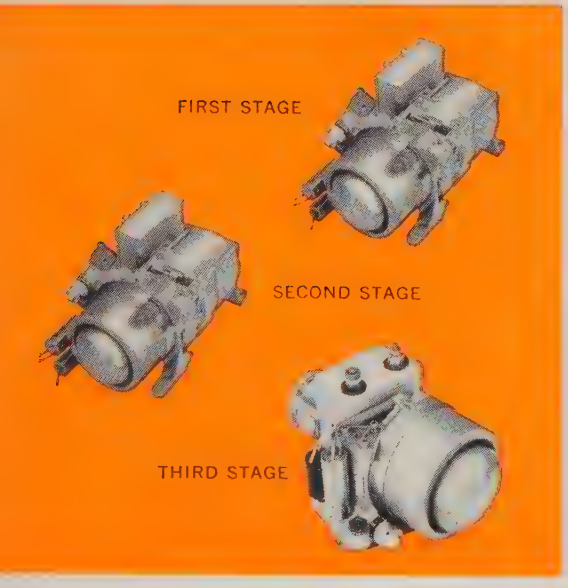
APPLICATION FLEXIBILITY—An important design feature is the ability of the hydraulic pump to be coupled with a wide variety of drives including continuous duty electric motor, ram air turbine, hydraulic motor, flywheel, or be mounted directly on an engine drive pad. For the Minuteman application, an intermittent duty d-c motor is used.

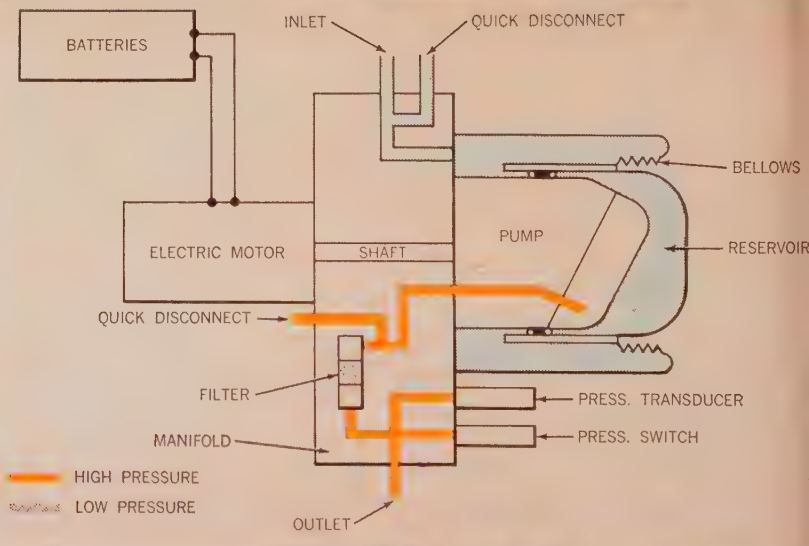
UNUSUAL STORAGE LIFE—A fundamental design goal of the Vickers Minuteman APU was to match the unusual storage life of the missile. This has been accomplished to provide long service-free standby in the missile, coupled with convenient ground check-out.

HIGH RELIABILITY—The schematic diagram below shows the absence of external tubing and the requirement for only one external dynamic seal. These factors along with a proven pumping element and relative low operating speeds have led to a highly reliable system.

This solution is typical of the Vickers "Programmed Power" approach to energy conversion, power transmission and fluid transfer. Get more details on this application by writing for Bulletin A-5249.







AERO HYDRAULICS DIVISION
VICKERS INCORPORATED
DETROIT 32, MICHIGAN
TORRANCE, CALIFORNIA

division of
SPERRY RAND
CORPORATION

PROGRAMMED POWER IN: FLUID TRANSFER • POWER TRANSMISSION • ENERGY CONVERSION

No. 116 on Reader Service Card

MAGNETIC REED SWITCH hermetically sealed

A magnetic reed switch has been designed for use in various types of limit indicators, position indicators, and relays. This DRG-1 switch operates in any position, and is hermetically sealed for use under any atmospheric conditions. It is reported not to be affected by extreme temperatures or pressures.

Manufactured by **Hamlin, Inc., Dept. S/A, Lake Mills, Wisc.,** the DRG-1 is rated at 15 volt-amperes, resistive up to 1 amp, to 250 volts. Arangements can be normally open, normally closed with bias magnet, and a latching arrangement. The contact reeds are gold-plated.

No. 273 on Reader Service Card

FILTERS for exotic fluids

A new line of filters from **Dynatrol, Inc., Dept. S/A, 95 Liberty St., New York 6, N. Y.,** is specially designed to handle high pressure gases, propellants, crogenic and other exotic fluids.

The 59S-L and 49S-L filters are available in both inline and tee configurations. They are rated at an operating pressure of 3500 psi on standard units (with higher ratings available on request) through a temperature range of −321 to 1300 deg F. Standard sizes range from 1.5 in. through 6 in. for filtration to 2 microns. Any standard type will be modified to meet specific operating requirements, Dynatrol reports.

No. 274 on Reader Service Card

BRAKES, CLUTCHES offer high torque

A new line of size 5 brakes and clutches has been announced by **Clifton Precision Products Co., Inc., Dept. S/A, 5050 State Rd., Drexel Hill, Pa.** It is said to offer the highest torque per watt in the industry.

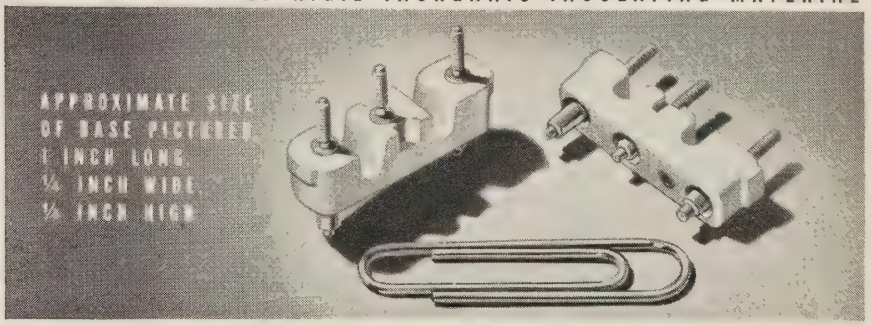
Torque at 28 V DC excitation for the clutches is reported to be: engaged (minimum), 6.0 oz/in; disengaged (maximum), 0.05 oz/in. Brake torque (minimum) is 2.0 oz/in. The new units are said to feature a "no-creep" design that eliminates angular displacement with clutching or braking, and to make use of new materials that eliminate loss of torque during life. They exhibit no torque variation with fluctuating temperature up to 125 deg C, according to the manufacturer. They are designed to MIL-S-20708, and meet requirements of MIL-E-5400 and MIL-T-5422.

No. 275 on Reader Service Card

Here's How Haveg Solved the Problem...

with HAVELEX®

PRECISION MOLDED RIGID INORGANIC INSULATING MATERIAL



This miniature switch base molded with Havelex, contains four different stainless steel inserts with precious metal plating. Three inserts (which include #0-80 male threads) go all the way through the mold and provide precision mountings on both sides for assembly. The #0-80 female threaded insert is designed to protrude from one face and is approached by a molded counterbore from the other. Mold is designed to accommodate alternate terminal inserts when unthreaded models are required.

Haveg engineers recommended Havelex for this particular molding because of its combination of properties. Completely inorganic, with metal inserts integrally molded in place. Precision tolerances with faithful reproduction from part to part. Heat resistance for continuous operation in excess of 700°F.

Haveg engineers will be happy to work with you on your particular project—to help you "Keep ahead with Haveg." *Remember*—Havelex offers all of these unique features: **Dimensional Stability • 1000°F. Continuous Temperature Resistance • Dielectric Strength • Mechanical Strength • Low Loss, Low Power Factor • Arc Resistance • No Moisture Absorption • Integrally Molded Metal Inserts • Hermetically Sealed Inserts.**

Keep Ahead with HAVEG FIRST IN *Engineered* PLASTICS

TAUNTON DIVISION
HAVEG INDUSTRIES, INC.
336 Weir Street • Taunton, Massachusetts
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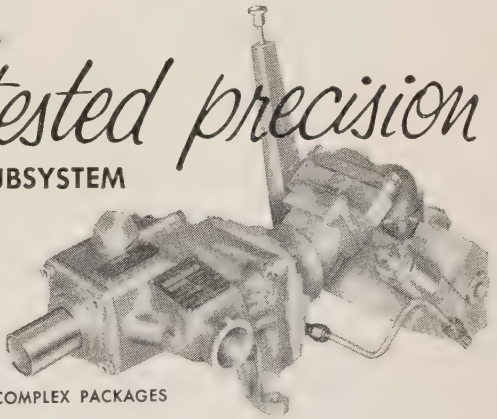
No. 117 on Reader Service Card

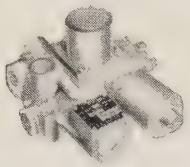
MC

missile-tested precision

IS ASSURED IN SUBSYSTEM DESIGN AND MANUFACTURE



COMPLEX PACKAGES



SOLENOID VALVES

RELIEF VALVES

ALSO Shuttle, Relief, Transfer, and Brake Valves; Compressors; Pressure Reducers.

Whatever your component requirements may be you will find our complete facilities are integrated for thoroughness and precision at every step—synchronized design, functional development and modern, efficient production, guaranteed by experienced testing. We invite your inquiry for a simple valve, a complex subsystem or anything new that demands imagination and experience.

WRITE, WIRE, or PHONE for data, quotations, and service

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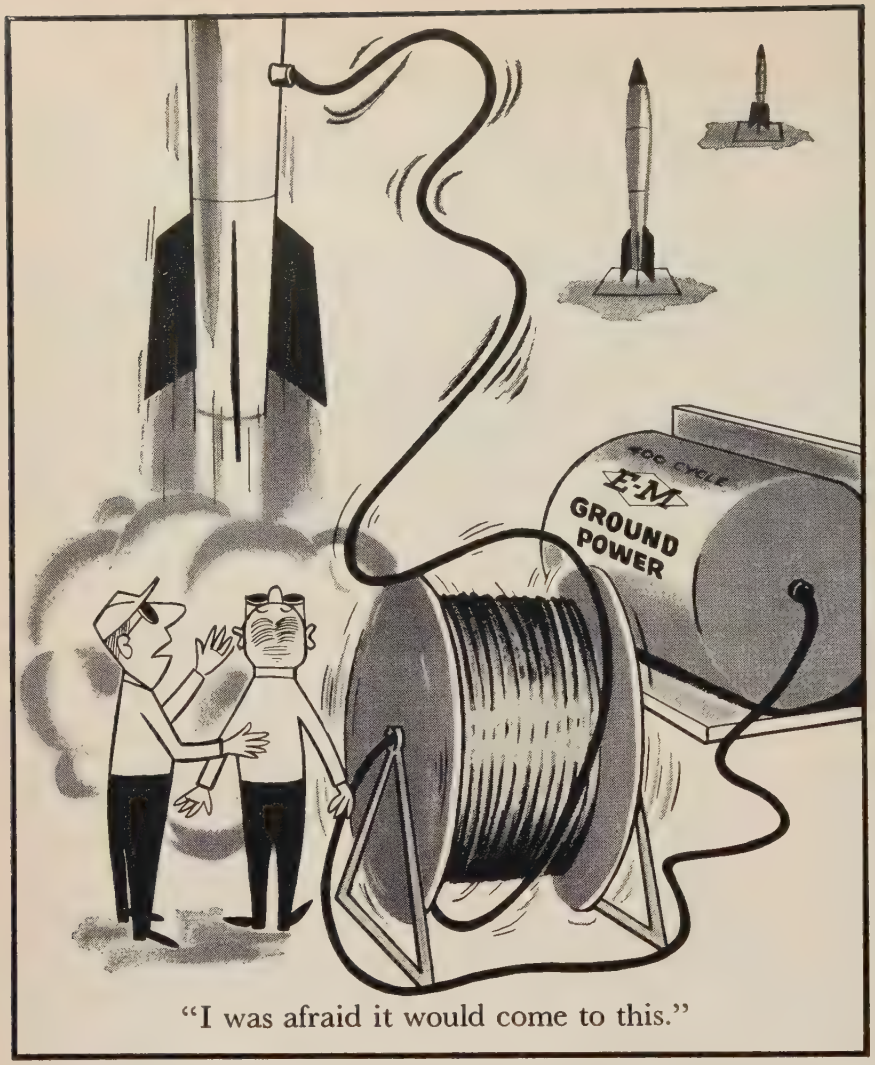


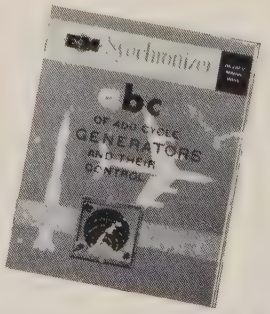
"I was afraid it would come to this."

Ground Power Problems? ...Here is the Answer!

Whatever your requirements in 400 cycle ground power equipment, E-M's large staff of specialists, with unmatched 400 cycle generator experience, can help. Missiles and jet aircraft that now have the advantages of E-M's imaginative engineering of 400 cycle ground power generators include Titan, Nike-Hercules, Snark, Matador, Hound Dog, B-47, B-58, and B-52.

Designing and building 400 cycle generators to meet the exacting requirements of missile and jet applications requires a big investment in experienced, technical manpower and plant facilities. Ask your nearby E-M Field Engineer to show you his copy of "Ground Power for Space". It's an informative picture story of E-M's investment in your 400 cycle ground power needs.

FREE 28-PAGE ILLUSTRATED BOOKLET offers many answers to your 400 cycle ground power questions. Write the factory for a free copy of "ABC of 400 Cycle Generators and Their Control". It's packed with useful information about performance characteristics and mechanical construction of 400 cycle ground power generators.



E-M
2600-TPA-2220

ELECTRIC MACHINERY MFG. COMPANY
Minneapolis 13, Minnesota

DC POWER SUPPLY has mag-amp regulation

A militarized DC power supply with an output of 28 volts at a continuous-duty rating of 10 amps has been added to the line of power supplies available from **Perkin Engineering Corp., Dept. S/A, El Segundo, Calif.**

This model M-1560-1 features magnetic amplifier regulation, with no tubes or moving parts. The base plate mounting makes it adaptable for use in almost any module or rack mount. Hermetically sealed rectifiers are used for high temperature operation. Regulation is ±1 per cent for combined variations of line and load. Ripple is 3 per cent rms max.

No. 276 on Reader Service Card

SELECTOR VALVE uses sliding seals

A new miniature 3000 psi selector valve for directional flow has microfinish sliding seals. This 2 in x 2 in. valve is being introduced by **Republic Manufacturing Co., Dept. S/A, 15655 Brookpark Rd., Cleveland 35, Ohio.**

The seals are wear-compensating, wiping the surface clean as they move across the ports. Line pressure aids sealing. The valve body is forged aluminum alloy, with stainless steel internal parts. The valves are available in 2-, 3-, or 4-way types, sizes ⅛ in. and ¼ in., with internal straight thread gasket seal and internal pipe thread connections.

No. 277 on Reader Service Card

BEARING SCREW offers choice of types

The "Roton" bearing screw is described by its manufacturer. **The Anderson Co., Dept. S/A, 1075 Grant St., Gary 40, Ind.,** as the only linear actuator to offer a choice of operating characteristics and linear advancements in the same screw lead.

Two types are available—the Planetary and the Positive. The Planetary Drive bearing screw provides planetary action of the caged bearings around the screw, resulting in a mechanical reduction of linear advancement relative to the screw lead, and also features "freewheeling" motion at end of travel for complete protection of the bearing screw assembly, motor, intervening gears, drive pins, etc. The Positive Drive type is designed to produce constant positive linear advancement for applications which require a fixed relationship between linear advancement and input revolutions. It is adaptable to multiple screw applications requiring synchronized advancements.

No. 278 on Reader Service Card

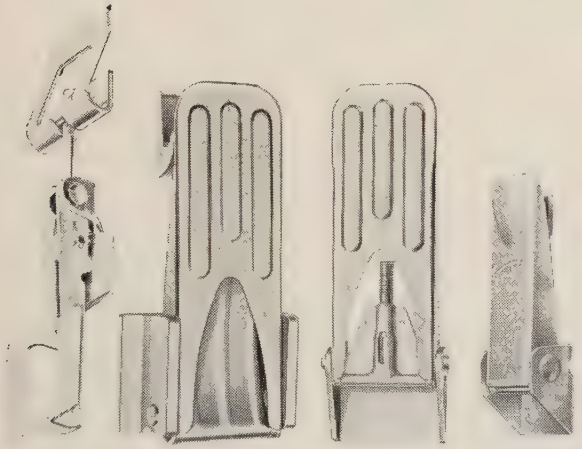
No. 119 on Reader Service Card

There's a Camloc Fasten/eered Universal Latch to do the job... and do it better!

You may never have to crate an anteater or ship a zebra. It's just one way of demonstrating the wide range of tensile strength requirements met by Camloc Universal Latches. For any job . . . from A to Z . . . 500 pounds or 4500 pounds . . . shipping containers or component assemblies of any size . . . Camloc can provide the latch to fill your specifications.

At Camloc the science of modern fastening is called FASTEN/ATION. And, FASTEN/EERED Camloc latches provide the ultimate in protection, ease of installation, and simplicity of operation. For example: draw hooks always stow flat when latches are open. Latches can't open under shock or vibration. Clean, crisp appearance enhances any product or component.

Have a special fastening or closure problem (even a reusable zebra case)? Camloc can provide a FASTEN/ATING solution. Write today for your copy of the full-line Camloc catalog.



37L — Ultimate tensile strength up to 4500 lbs. Short or long handle types.

46L — Ultimate tensile strength up to 1000 lbs. Aluminum or steel mounting bases and hooks.

46L (with adjustable draw hook) — All the features of type 46L plus draw hook adjustable over a ½" range.

51L — Ultimate tensile strength up to 500 lbs. Hook adjusts by simple rotation over 5/16" range.

specialists in fasteners for industry

CAMLOC

CAMLOC FASTENER CORPORATION, 13 SPRING VALLEY RD., PARAMUS, N. J.
West Coast Office, 5455 Wilshire Blvd., Los Angeles, California • Southwest Office, 2509 W. Berry St., Fort Worth, Texas
European Subsidiary: Camloc Fastener GmbH, Kelkheim/Taunus, West Germany

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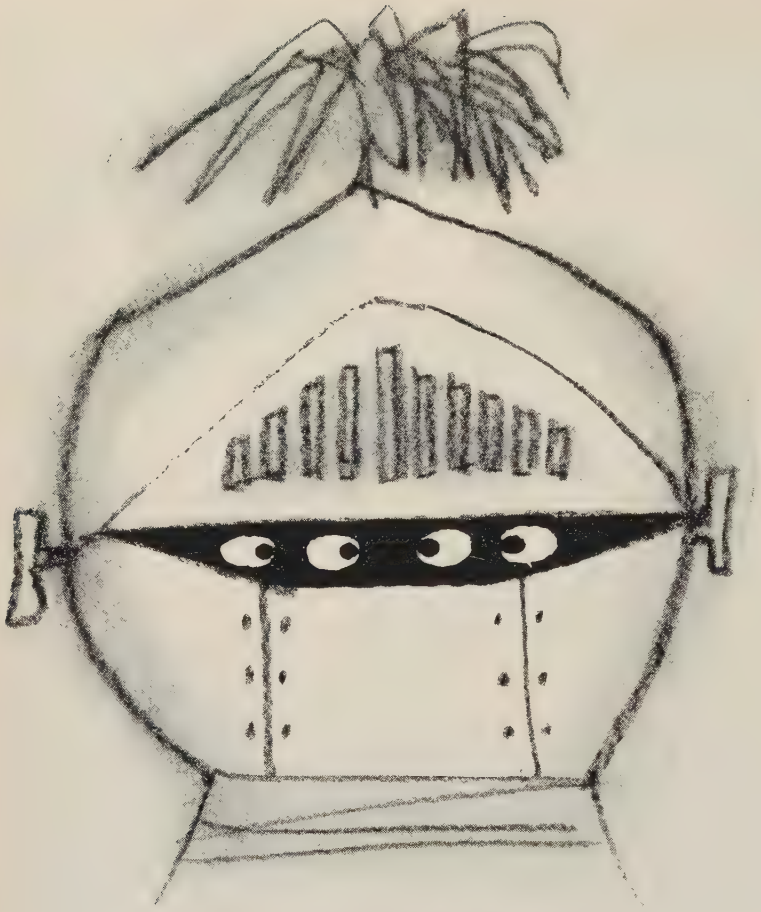
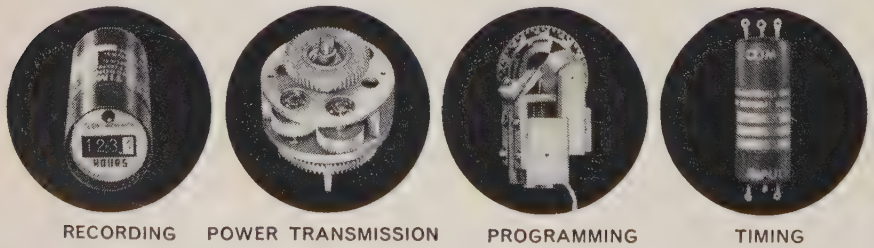
No. 120 on Reader Service Card



TOGETHERNESS:

This little piece could have been titled "Look again, Lancelot" or "Jousting Cheek to Cheek." Then we'd whip up an amusing little allegory and lead into a clever punch line . . . but there isn't room, so we'll come right to the point. Elgin Micronics is specially organized and qualified to work with your staff on any project involving sub-miniature precision component assemblies—mechanical, electro-mechanical or electronic—at any stage from concept and basic research through quantity production. Let's put our heads together.



RECORDING POWER TRANSMISSION PROGRAMMING TIMING

ELGIN MICRONICS

DIVISION OF ELGIN NATIONAL WATCH COMPANY 366 Bluff City Blvd., Elgin, Illinois

Plants in Elgin and Rolling Meadows, Illinois and Chatsworth, California

Represented nationally by Airsupply-Aero Engineering Company, a division of The Garrett Corporation

CHECK VALVE
bars reverse fluid flow

This miniature in-line check valve permits free fluid flow in one direction and checks reverse flow. It is designed with one end for installation into a valve body and the opposite end for tube connection, says **Fluid Regulators Corp., Dept. S/A, 313 Gillette St., Painesville, Ohio.** It weighs less than 1 oz.

The valve is built for operating pressures up to 1000 psi. The valve cracks at 5 to 8 oz /in. and has a flow capacity of 1.0 gpm. It handles any fluid compatible with the materials in a —65 deg F. to +450 deg F. temperature range.

No. 279 on Reader Service Card

MISSILE BATTERY
activates in one second

A low weight, small size, silver zinc primary battery for missile applications is offered by the **Electric Storage Battery Co., Missile Battery Div., Dept. S/A, P. O. Box 11301, Raleigh, N. C.**

The 24-V Model 79 battery automatically activates within 1 sec and has a discharge time of 0.83 min when discharged at 10 amps, the manufacturer reports. It has a capacity of 0.14 amp-hr and delivers 3.06 watt-hrs per lb and 0.19 watt-hrs per cu in. It is said to perform reliably at altitudes up to 50,000 ft, within a temperature range of —65 to 160 deg F, at any position of the missile. The Model 79 weighs approximately 1.10 lb, and measures 2 in. high x 1.50 in. wide x 6 in. long. Its heat-up time is 15 min, activated stand time is 1.5 hr, and estimated shelf life is 5 yr.

No. 280 on Reader Service Card

LONG-LIFE GAGE
for high pressure applications

A new gage for pneumatic or hydraulic service in military, missile, and other high pressure applications has been developed by **American-Standard, Controls Div., Dept. S/A, Detroit 8, Mich.** Designated the Rochester Series 6925 High Pressure Gauge, the unit is reported to offer a life expectancy of more than 250,000 cycles.

Series 6925 gages are designed to provide continued accuracy of pressure measurement under extreme conditions of overload pressures, high vibrations, shock, or line pulsation. Tests covering more than 100,000 cycles indicate that gage accuracy increases through continued use, according to American-Standard. Overall accuracy is maintained for ±¼ per cent, and hysteresis, friction, and backlash are below readable limits.

No. 281 on Reader Service Card

No. 121 on Reader Service Card

P-e-e-l-i-n-g Off to Flight Precision

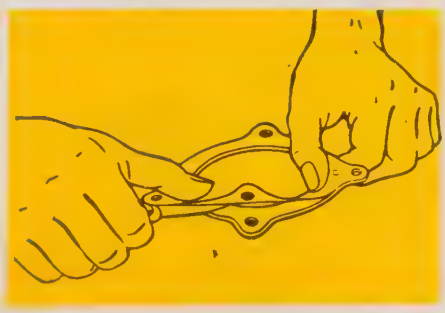
It's a Shim made of LAMINUM® of course, meeting the close tolerances of sophisticated aircraft in a matter of seconds!

LAMINUM is the registered name for laminated shim stock that looks and acts like solid metal. Plastic bonded or metallic bonded, the laminations p-e-e-l off easily to give you a thousandth fit—right at the job.

No machining. No grinding. No counting. No stacking. No miking. And no costly stand-by equipment.

Shims of LAMINUM, custom-made to your own rigid specifications are quickly available from the oldest specialists in the country—serving aircraft and all metalworking since 1913! In Brass, Mild Steel, Type 302 Stainless and in Aluminum—with laminations of .002″ or .003″. **And now also in Titanium with laminations of .003″!** Any shape. Any size. Any quantity.

An inquiry will bring you the time-saving, cost-saving story of LAMINUM along with our recently published DESIGN FOLDER NO. 4 with complete up-to-the-minute engineering data. If you're in a hurry—phone Templebar 6-1440 in Oakland, or Davis 5-2631 in Glenbrook.



THE LAMINATED SHIM COMPANY, INC.

Home Office and Plant: 5308 Union St., Glenbrook, Conn. • West Coast Sales and Service: 600 Sixteenth St., Oakland 12, Calif.

No. 122 on Reader Service Card

Taber transducers probe rocket engine performance at Bell

The ruggedness, reliability and versatility of Taber Teledyne pressure transducers are amply demonstrated here. In this Bell Aerosystems' rocket engine test, six Taber bonded strain gage transducers are measuring chamber, hydraulic, valve actuation, tank, fuel and oxidizer pressures.

Three of the instruments (C, D, and F) have been in service at Bell for *more than 7 years!* The others are more current compact designs.

Taber transducers are available in a wide variety of models for test, ground support and airborne applications in pressure ranges from 0-50 to 0-10,000 psi. High frequency response, minimum hysteresis, infinite resolution and low sensitivity to temperature effects, vibration and shock are among their many plus features.

For illustrated literature, attach this coupon to your letterhead and mail.

TO: TABER INSTRUMENT CORPORATION
AEROSPACE ELECTRONICS DIVISION SECTION 36
107 Goundry Street, North Tonawanda, N. Y.

Send detailed information on Taber Teledyne and Teleflight bonded strain gage pressure transducers.

name _____ title _____

company _____ dept. _____

address _____

city _____ zone _____ state _____

No. 123 on Reader Service Card

MINIATURE CONVERTER for aircraft use

Model 100 PS DC-DC miniature converter has been designed to convert battery power to primary power for aircraft, missile, and industrial applications. Available from **Johnson Electronics, Inc., Dept. S/A, P.O. Box 1675, Casselberry, Fla.,** this unit is completely transistorized, and can be supplied with either germanium or silicon transistors, depending upon temperature applications.

Specifications are: input—12 volts DC; output—250 volts DC, 75 watts; weight—1.5 lbs approx; size 4-¼ x 3-¾ x 2-¾ in.

No. 282 on Reader Service Card

METERING VALVE is extremely small

An extremely small globe-type metering valve with male ports, 14,000 psi burst pressure, has been developed for use with gases such as nitrogen, oxygen, and helium, and liquids such as fuels, hydraulic oils, and water.

Introduced by **Robbins Aviation, Inc., Dept. S/A, 2350 E. 38 St., Los Angeles 58, Calif.,** the INS736 valve has a body that measures 0.75 in. x 0.75 in. x 1.75 in., including the 2 male ports. Operating torque is 4 in.-lb at 2500 psi. Operating pressures are high-vacuum to 3500 psi. Weight is only 0.31 lb.

No. 283 on Reader Service Card

ALL-METAL SEAL resists extreme temperature

An all-metal seal is featured in a new series of cryogenic and high temperature couplings from **Gamah Corp., Dept. S/A, 1654 Lincoln Blvd., Santa Monica, Calif.**

The seal is said to maintain an absolutely tight joint for all extremes of temperature, shock, pressure surge, and vibration. It is reusable and reversible.

No. 284 on Reader Service Card

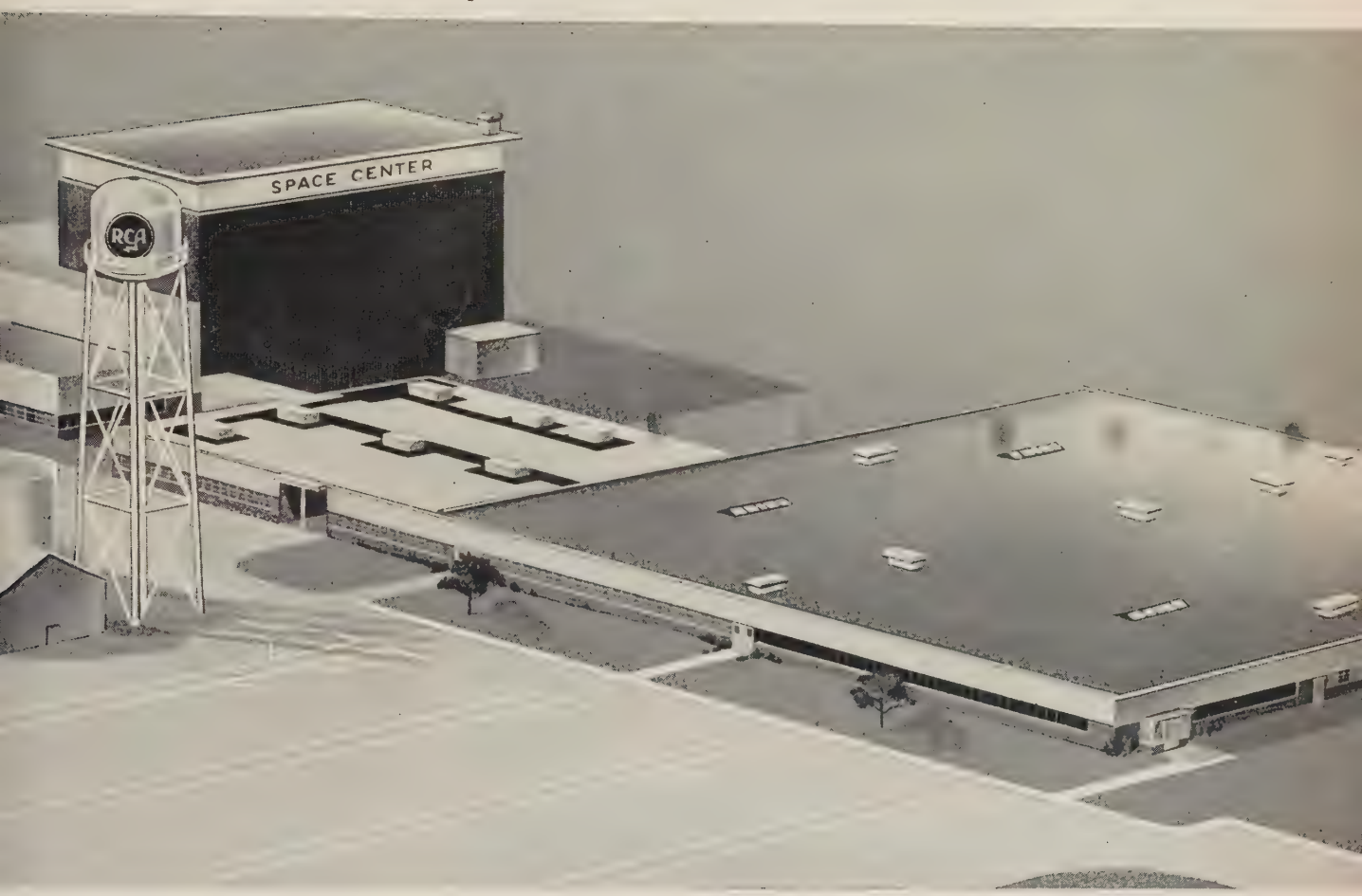
RATE GYRO is miniaturized

A miniature rate gyro from **Summers Gyroscope Co., Dept. S/A, 2500 Broadway, Santa Monica, Calif.,** measures only 1 in. in diameter and weighs 6 oz. Designated the Model 584, it is reported to offer simple design and high reliability.

Intended for spacecraft, missile, and general aircraft applications, the gyro is said to exhibit unusually good hysteresis characteristics. A unique fluid damping principle results in damping through wide temperature ranges, the manufacturer reports.

No. 285 on Reader Service Card

New RCA Space Environment Facility Brings Outer Space Down to Earth...



... Will pretest coming generations of U.S. space vehicles and satellites at environmental extremes assuring reliable long life operation and optimum performance.

Included in the new environmental equipment and facilities being built and installed at the RCA Astro-Electronics Division at Princeton, N.J., are the following advanced testing devices:

Vacuum-Thermal Chamber — measuring 28 feet in diameter and 25 feet high to accommodate the coming generations of space vehicles and satellites and meet all vacuum-thermal requirements.

Vibration System — provides 28,000 pounds peak force for sinusoidal, and 28,000-pound rms force for random motion testing.

Temperature-Humidity Chamber — so versatile it can create virtually any thermal-humidity condition desired. Temperatures may be varied from —85° F to 250° F; humidity from nil to maximum.

Rotary Accelerator — subjects subsystems of space vehicles and satellites to forces as high as 2500 g lbs.

The entire RCA Space Center, which contributed to the success of projects such as SCORE, TIROS I, TIROS II and ECHO I, continues to be dedicated to the conception, development and production of earth satellites, space vehicles and ground support and information handling equipment. For additional information about RCA's engineering talents and proved capabilities, contact the Manager, Marketing, RCA Space Center, Box 800, Princeton, N. J. And, for a complete description of the new environmental facilities, write for your copy of the brochure "RCA Space Environment Center."

RCA®

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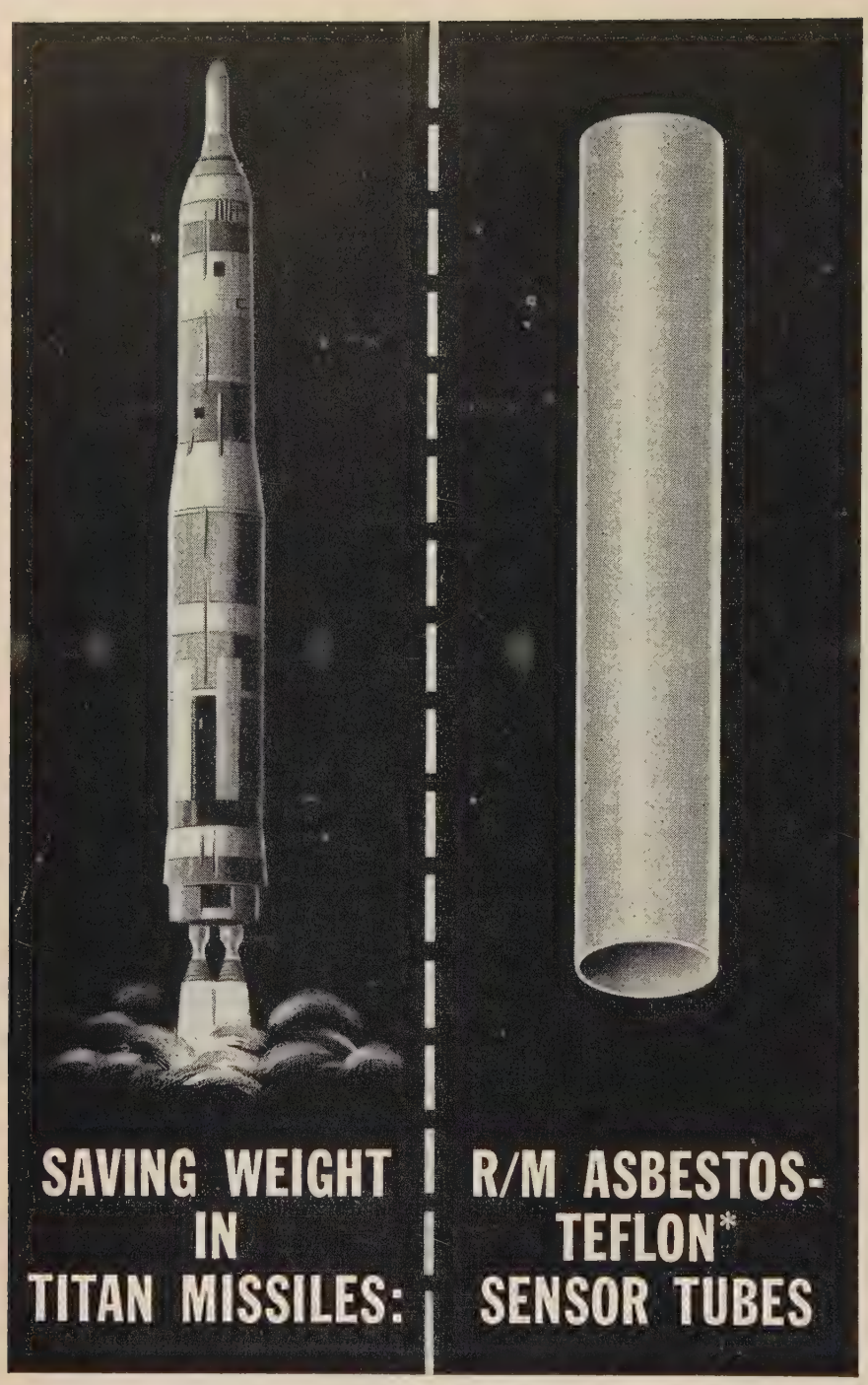
RADIO CORPORATION OF AMERICA



A new combination of high-heat materials, perfected by R/M, has reduced the weight of sensor tubes which help determine fuel load in Titan missiles.

These tape-wrapped tubes, 4 in. ID, 12 ft. long, weigh less than 0.67 lb. per foot—a substantial weight saving over any competitive tubes which meet the temperature, fuel compatibility, and strength/weight ratio requirements.

This is but one of the many applications in which R/M specialists are using their extensive "Teflon" experience to help missile and airframe manufacturers solve weight, compatibility, temperature and strength problems.

Write direct or call your nearest R/M district office listed below.

*Registered TM for Du Pont fluorocarbon resins

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No. 124 on Reader Service Card

ROTARY FACE SEALS for minimum envelope

Special bellows type rotary face seals for use where minimum envelope length is required have been developed by **Hydrodyne Corp., Dept. S/A, 7350 Coldwater Canyon Ave., N. Hollywood, Calif.** The units are used in Oronite 8200 systems.

The design features a short, one-piece, precision machined bellows, heliarc welded flush to the flange type mount, with a graphite carbon seal recessed in the housing to accommodate the shaft wear ring within the envelope length of the rotary face seal assembly. The manufacturer reports that the stainless steel assembly is subjected to 2200 psi surge pressures and a normal operating pressure of 500 psi, while actual burst pressure is in excess of 5000 psi. Temperature range is said to be —65 to 520 deg F.

No. 286 on Reader Service Card

MOUNTING SYSTEMS for aerospace units

Elastomeric mounting systems are being produced for aerospace designs requiring integration of black boxes and protective structures. The members used provide all-attitude control of high frequency vibration, plus attenuation of shock and structure borne noise from —65 to +300 deg F., according to **Lord Manufacturing Co., Dept. S/A, Erie, Penna.**

In addition to controlling dynamic disturbances, the system will support various configurations on the same base, have integral cooling, and provide for quick-disconnect and electrical and tubing connections.

No. 287 on Reader Service Card

COUPLING TUBE offers superior seal

A high temperature, high pressure rigid tube coupling with a superior seal has been announced by **Resistoflex Corp., Dept. S/A, Roseland, N.J.** The "Dynatube" is said to maintain its seal under conditions of vibration, shock, pressure overloads, pulsing action or temperature variations.

These fittings are leak-proof, even under cryogenic conditions, and are not subject to torquing difficulties, according to the manufacturer. They provide absolute dynamic sealing for all liquids and gases up to 700 deg F, and 1000 deg F for certain applications. Testing has included 5000 psi hydraulic impulse pressure cycling with 7500 psi peaks, and also indicates that the seal is capable of handling 5000 psi helium. Dynatubes are available in sizes from —3 through —24.

No. 288 on Reader Service Card

Every step of the way through ENGINEERING, TOOLING, MANUFACTURING

Rohr provides a world of experience and capability in aerospace structures. Typical is the jet pod and thrust reverser program shown above. Rohr engineers developed design concepts, coordinating with customer design groups, then worked closely with Rohr research, tooling, testing and production people in all phases of manufacture. Result? Specifications met on time at minimum cost!

Chances are our unique blend of men, machines and experience can provide solutions to your structures problems. Write Mr. A. R. Campbell, Sales Manager, Department 57, Rohr Aircraft Corporation, Chula Vista, California.

Main Plant and Headquarters: Chula Vista, California / Plant: Riverside, California / Assembly Plants: Winder, Georgia; Auburn, Washington

No. 125 on Reader Service Card

COUNT DOWN

these advantages of Tayloron* Reinforced Plastics in high-performance assemblies

6

High strength-to-weight ratio. In terms of weight, reinforced plastics are considerably stronger than most metals. Moreover, their strength characteristics may be directed where stresses demand. In filament or tape wound shapes, highest properties may be obtained.

5

Comparative rigidity in cured condition. This property prevents the reinforced plastic part from bulging or otherwise deforming when high pressures or other stresses are present. Thus original tolerances can be maintained under adverse operating conditions.

4

Excellent corrosion resistance. High resistance to both atmospheric and chemical corrosion is a feature of reinforced plastics. This is particularly important in structural members where corrosion could generate failure locations.

3

Low heat transfer. This, under extremely high temperatures, makes Tayloron ideal for protecting structural members in missiles.

2

Good ablation qualities. The capacity to keep on performing their basic function despite loss of some of their structure is an important characteristic true of some reinforced plastics. Tayloron materials offer the additional advantages of dissipating energy and thus reducing stresses on other members.

1

Ease of fabrication. A wide variety of shapes may be made to close dimensions by molding, laminating, or winding of filament or tape. Tayloron reinforced plastics are readily fabricated and machined.

How Taylor Can Help You

In your designing of components and assemblies, consult our Advanced Materials Division on how to choose the best material and minimize the cost in reinforced plastics. Taylor can supply complete fabricated assemblies—or materials for any test and evaluation program. Special Tayloron materials have been developed for many specialized applications. Write the Advanced Materials Division outlining your specific problem. Taylor Fibre Co., Norristown 54, Pa.

*Trade name for Taylor Fibre's space, missile and astronautic materials

Taylor

REINFORCED PLASTICS ■ VULCANIZED FIBRE

Composite laminates • Metallic and nonmetallic materials laminated with plastic resins in many combinations and many forms • Vulcanized fibre in sheet, roll or fabricated parts • Filament wound parts • Materials and components engineered to perform specific functions • Pre-impregnated materials in filament, tape, wide sheet or roll

MANIFOLD MOUNT for square head uses

This manifold mount and valve package permits application to pneumatic and hydraulic cylinders. It is said to be applicable to the J.I.C. square head interchangeable cylinder produced by several manufacturers, according to **The Gabriel Co., Dept. S/A, 1148 Euclid Ave., Cleveland 15, Ohio.** The package can be applied to cylinders up to four in. in diameter and 15-in. stroke, standard.

The unit is available in single and double solenoid models, as well as cam and lever operators. There are three pressure ranges, 0-300 lb, 300-1500 lb and 300-3000 lb.

No. 290 on Reader Service Card

INSTRUMENT COUNTER used in aircraft

Developed for aircraft instrument application, this miniature counter maintains a low friction torque over the full environment range, says **Melland Gear & Instrument Co., Inc., Dept. S/A, 88-06 Van Wyck Expressway, Jamaica 18, N.Y.**

The counter has a maximum torque of 0.1 oz-in-in. at room temperature, and will not exceed 0.25 oz-in. at extremes of —55 and +100 deg C. The unit can be run indefinitely at 350 rpm and for shorter periods at 600 rpm, says Melland. Drum diameter is 0.672 in. and the 0.187-in. numerals are spaced 0.150 in. apart. Up to five drums can be used.

No. 291 on Reader Service Card

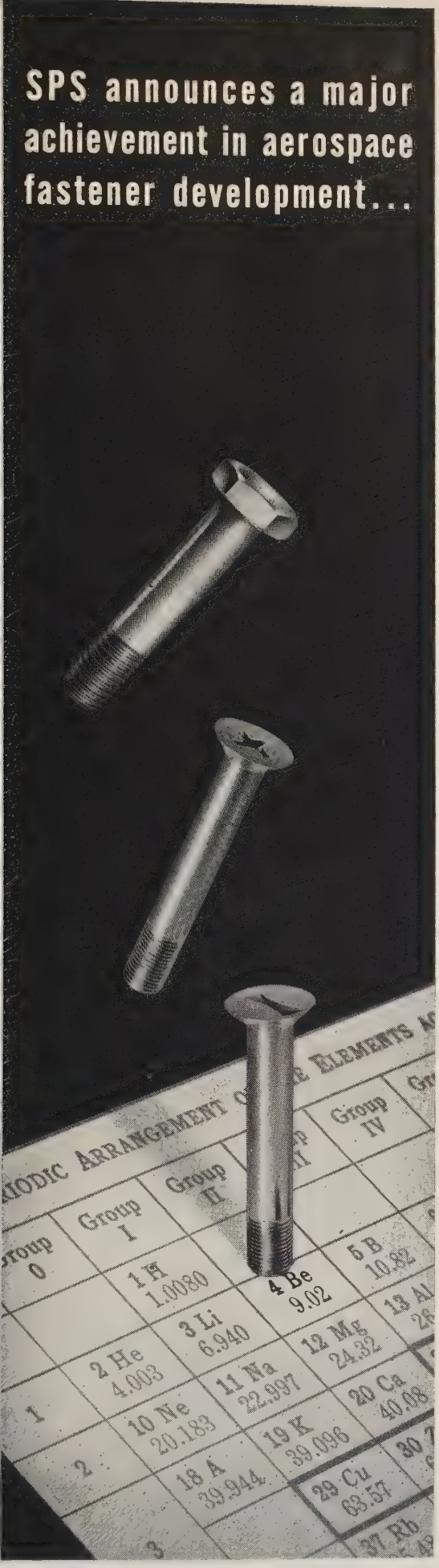
GYRO is subminiaturized

A subminiature rate gyro from **R. C. Allen Instrument Div., R. C. Allen Business Machines, Inc., Dept. S/A, Grand Rapids, 2, Mich.**, has a $1\frac{5}{16}$ in. diameter and an overall length of $2\frac{1}{2}$ in.

The fluid-damped, angular rate sensor is encased in a positive hermetic seal. Its synchronous, hysteresis-type motor is supported on radial bearings. Opposing springs restrain gyro precession, and a six-pole induction-type motor transducer functions as pickoff. The manufacturer reports that the gyro has a resolution below 0.03 per cent of maximum rate, is insensitive to 100 G shock along any axis, and has withstood 20 G vibration up to 2000 cps. Other critical specifications include: temperature, —55 to 80 deg C (standard) and up to 105 deg C on request; linearity, 0.5 per cent of maximum rate; zero calibration, 0.01 to 0.02 per cent of maximum rate; life, 1000 hrs minimum.

No. 292 on Reader Service Card

No. 126 on Reader Service Card



BERYLLIUM BOLTS FOR PRODUCTION USE!

Available in flush and hex heads

Out of SPS Research & Development Laboratories and Pilot Manufacturing plant has emerged the world's first reliable beryllium bolt.

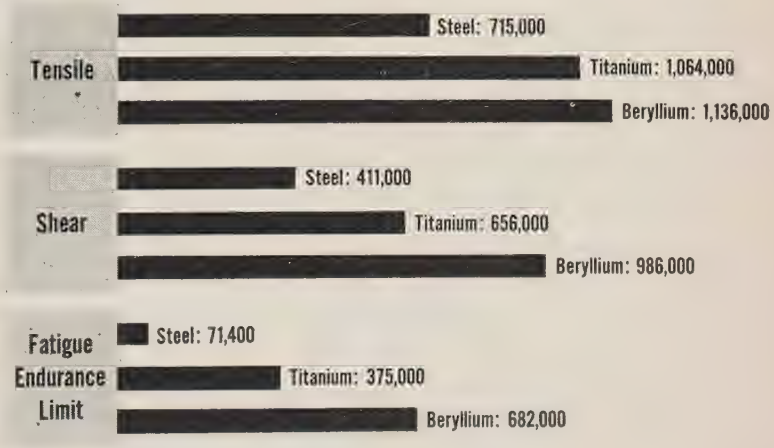
With a density of only .0658 lb. per cubic inch—less than one-fourth that of steel—beryllium can account for truly extraordinary efficiency in space projects. The current cost of orbiting a pound of satellite is reckoned at about $15,000. This would be the cost, then, for a pound of steel fastener with holding power of, say, 65,000 psi in shear. But the same quantity of beryllium fasteners of equal strength would weigh less than ¼ lb. So they would cost only about $3,750 to orbit.

Further proof of beryllium's superiority is the fact that today's fasteners of this material have a shear strength of 60,000 psi minimum. To achieve an equal shear strength-to-weight ratio, it would be necessary to use a heat-treated steel fastener having a tensile strength of 460,000 psi. Yet the strongest steel bolt known—another recent SPS development—is rated at 300,000 psi. First to produce a practical titanium bolt, SPS in its research and development work on beryllium faced several of the same problems posed by titanium . . . brittleness and notch sensitivity, for instance. But SPS, with fabrication techniques unmatched in the fastener industry, was able to overcome them. It was discovered that threads, constituting by far the most critical area, had to be rolled with a large, smooth radius. The ideal configuration was found to be a further development of the SPS Hi-R thread form, with a radius tangent to the flanks at a depth of 55%. The result? Fatigue life was increased sixfold.

In new designs where weight reduction is of critical importance, consider beryllium bolts . . . now being produced in quantity in three head configurations—"Hi-Torque" flush head, "Torq-Set" flush head and hex—for use in a wide variety of aircraft, missile and rocket applications. For further information, write STANDARD PRESSED STEEL CO.—manufacturer of precision threaded fasteners and allied products in many metals. AIRCRAFT/MISSILE Division, SPS, JENKINTOWN 54, PENNSYLVANIA • SANTA ANA, CALIFORNIA.

Comparison of mechanical properties—by strength-to-weight ratio—of beryllium bolts with steel and titanium bolts of NAS 464 configuration (values are given in stress/density units—psi/lb. per cu. in.)

Density of beryllium bolts	.066 lb./cu. in.
Density of titanium bolts	.16 lb./cu. in.
Density of steel bolts	.28 lb./cu. in.



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as resulted in amazing improved

uality and greater reliability in

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enables Parker to offer superior

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Compare Parker quality and reliability

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specify ANY O-Ring.

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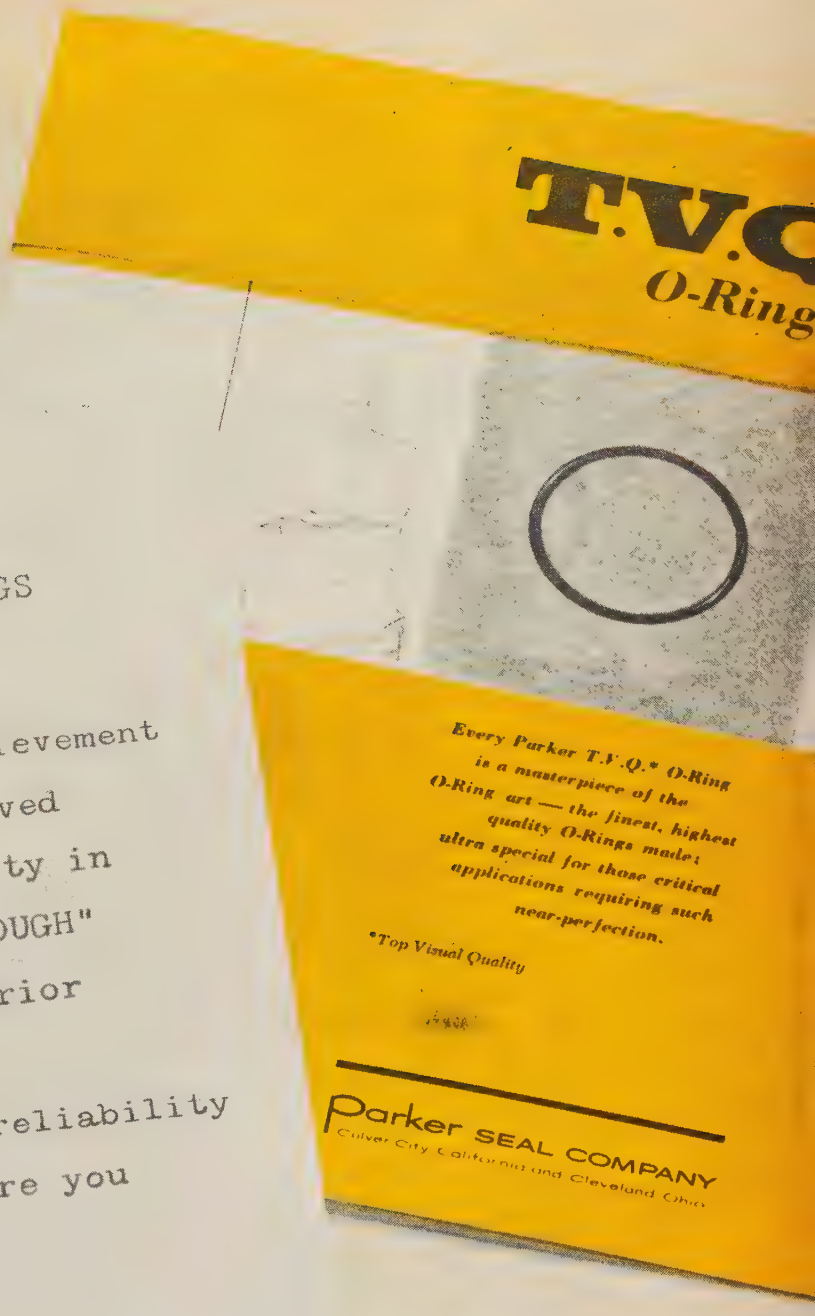
no finer O-Rings can be made!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O-Ring
Every Parker T.V.Q.* O-Ring is a masterpiece of the O-Ring art — the finest, highest quality O-Rings made; ultra special for those critical applications requiring such near-perfection.
*Top Visual Quality
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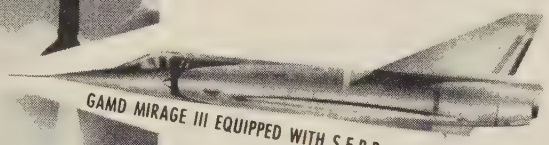
ONERA ANTARES MISSILE. 1st AND 3rd STAGES EQUIPPED WITH S.E.P.R. ROCKET ENGINES

LIQUID AND SOLID PROPELLANT ROCKET ENGINES



GAMD MIRAGE III EQUIPPED WITH S.E.P.R. 84-1 ROCKET ENGINE

Société d'Étude de la Propulsion par Réaction

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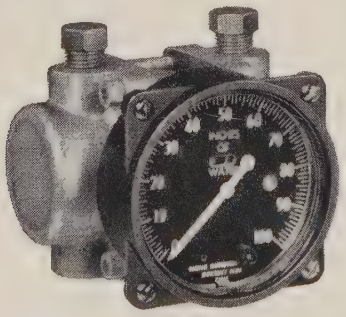
IGEP

No. 129 on Reader Service Card

COMPACT DIFFERENTIAL PRESSURE INDICATOR



INDICATES FLOW, LIQUID LEVEL, OR DIFFERENTIAL PRESSURE OF CO_2, OXYGEN, NITROGEN, HELIUM, HYDROGEN AND ARGON.

Widely used in jet engine and missile test programs and in ground support equipment, the Barton Model 226 Differential Pressure Indicator is a compact, lightweight and rugged instrument. It is highly reliable, and accurate within ±½% of full scale differential pressure. The actuating unit is rupture proof and immune to overranging. Differential pressure ranges are available from 0-40" w.c. to 0-400 psi; static pressures up to 6000 psi. Specified by major producers of liquefied gases. For complete specifications & data, request Bulletin 226-1.

BARTON® INSTRUMENT CORPORATION

580 MONTEREY PASS ROAD • MONTEREY PARK, CALIFORNIA

No. 130 on Reader Service Card

INERTIA SWITCH
has one moving part

This miniature inertia switch, Model 6UO-200 is pre-set to respond to acceleration forces up to 250 g within a tolerance of ±15 per cent of setting. It is designed with one moving part, a precision-ground steel ball held against a solid base by a uniform magnetic field, according to **Inertia Switch, Inc., Dept. S/A, 311 W. 43rd St., New York 36, N. Y.** When the opposing force of acceleration exceeds the magnetic force, the ball moves to close a normally open electrical contact.

The unit meets environmental specifications of Mil-E-5272, including an operations range of —65 to +200 deg F.

No. 293 on Reader Service Card

INTEGRATING GYRO
used in missiles

A line of miniature, lightweight floated rate, integrating gyros, designed for missile use, features an external adjustment to provide maximum ease of fabrication and calibration. Developed by **Kearfott Div., General Precision, Inc., Dept. S/A, 1150 McBride Ave., Little Falls, N. J.,** they include a mechanical mass unbalance adjustment along spin and input axes and an adjustment for spin axis alignment. Also featured is mass stability of the motor-float assemblies.

Characteristics of a typical unit, model M2514-01A, are: angular momentum—100,000 gm-cm²/sec; gimbal freedom—±10 deg; operating temperature—115-185 deg; drift—0.03 deg/hr vertical, 0.05 deg/hr azimuth; mass unbalance—1.0 deg/hr; anisoelastic error—0.01 deg/hr/g²; and maximum altitude limit—none.

No. 294 on Reader Service Card

SWITCH LIGHT
provides diversification

It is now possible to change bulbs, colors, lenses, or legends in this new series of switch lights, without the use of any special tools. Available from **Master Specialties Co., Dept. S/A, 956 E. 108 St., Los Angeles 59, Calif.,** they provide for front panel mounting and may be vertical, horizontal, or matrix. The line is said to include 2PDT and 4PDT momentary, 2PDT alternate action, and magnetic holding switches. Each unit accepts four bulbs and has corrosion piercing bulb contacts.

According to specifications, the switches are rated for 20 g shock for 10 milliseconds in all three planes, 10 g vibration to 500 cps, dielectirc of 1000 volts rms min at sea level, and insulation resistance of 100 M minimum.

No. 295 on Reader Service Card

DISC VALVE
for ICBM propellants

A hermetically sealed shearable disc valve has been developed for valving ICBM propellants. These valves, developed by **B. H. Hadley, Inc., Dept. S/A, 1427 So. Garey Ave., Pomona, Calif.,** are also suited for other airborne missile systems, emergency dump and vent operation, and various critical fluid storage uses.

Before shearing, the valve features a non-aging metallic disc that provides zero leakage indefinitely, according to Hadley. Actuation is rapid, either by pneumatic, hydraulic, or squib action. In the open position, there is full flow with minimum pressure drop. The sheared disc is retained completely, and no fragments are released into the fluid stream. On reclosure, after shearing, leakage is reported exceptionally low. The valve is obtainable in either butterfly or poppet design.

No. 296 on Reader Service Card

TRANSDUCER
has compact design

A new transducer from **Vinson Mfg. Co., Dept. S/A, 8044 Woodley Ave., Van Nuys, Calif.**, is said to incorporate electrical features of the linear differential transformer through use of a new compact design which includes transformer and rotary to linear converter in the same housing.

The GM 9060 angular position transducer has a temperature range from −65 to 300 deg F. Linearity is ±½ per cent; sensitivity 5 V full scale; input 26 V at 400 cps; phase shift 3 deg maximum with an external capacitor. Transducers in this series are available with full scale displacements from ±40 deg to ±10 revolutions, or more, the manufacturer reports.

No. 297 on Reader Service Card

PLUG VALVES
have Teflon sleeves

These instrument plug valves which have screwed ends are available in sizes of ¼ through one inch. They are designed for on-off use over a temperature range of from−50 to + 400 deg F with gaseous or liquid corrosive and non-corrosive fluids, according to the **Continental Manufacturing Co., Dept. S/A, 230 Park Ave., New York 17, N.Y.** The valves are rated for 300-lb service.

No lubrication is needed because all moving parts are supported by low-friction Teflon, says the company. Shut-off is leak proof even under conditions of fluctuating temperature, they report.

No. 298 on Reader Service Card

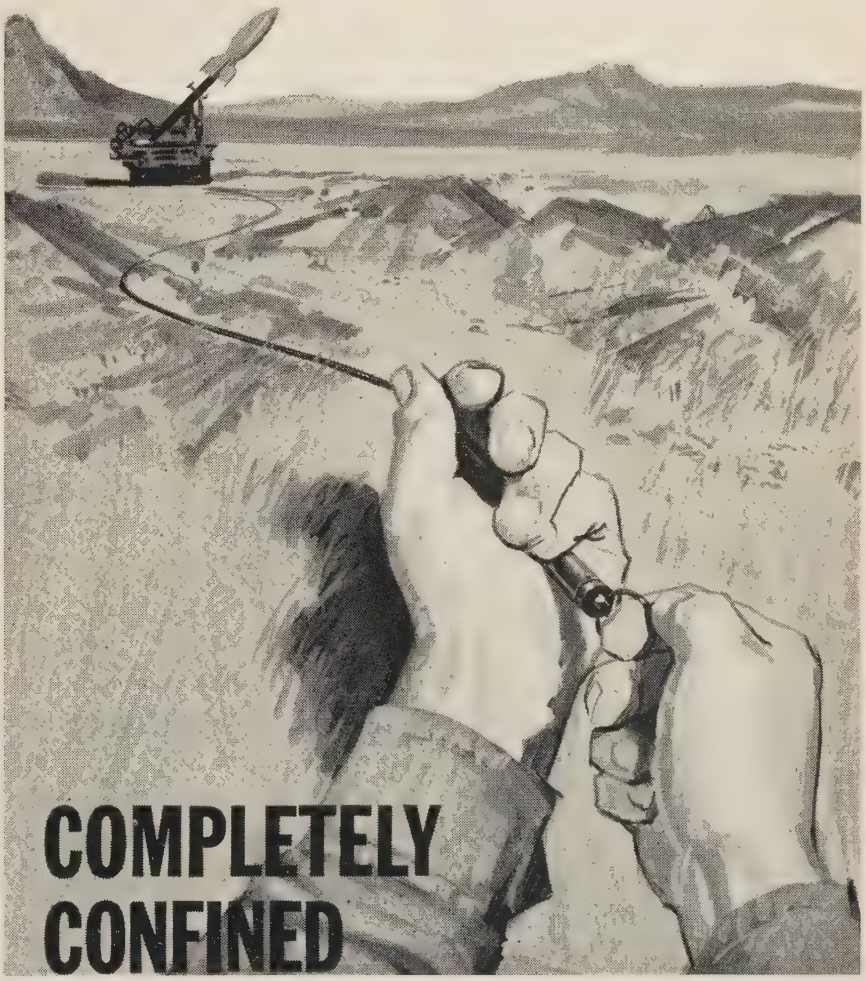
TERMINAL
allows high production rates

A lightweight terminal for mounting electronic components at high production rates has been announced by **Pacific Coast Electronics Corp., Dept. S/A, 2457 Chico Ave. S., El Monte, Calif.**

The Tri-El terminal is a formed stamping that mounts to a terminal board with a simple staking tool. It provides one connection on top of the board and two below, allowing greater flexibility than conventional turrent type terminals. Stamped from brass or beryllium copper, the Tri-El unit is also reported to exhibit remarkable performance when subjected to shock or vibration, exceeding requirements for vibration stability outlined in military specifications, and to offer assembly time savings to 50 to 75 per cent. The terminal is available as individual units ready for mounting, or already mounted on standard or custom terminal boards.

No. 299 on Reader Service Card

Ask your **Du Pont Explosive Systems Specialist** *about:*



MILD DETONATING FUSE
Protection against RF energy

This new and unique ordnance device enables you to transmit a uniform, high-velocity detonation for unlimited distances—*with essentially no risk of damage to adjacent components.*

You can get Du Pont Completely Confined Mild Detonating Fuse (MDF) in a variety of explosive trains, encased in concentric sheaths of metal, plastic, and fiberglas. It is far more insensitive to physical shock and RF energy than conventional electric systems, but can be easily fired non-electrically.

The protective jacket shields it against stray electrical currents such as those emitted by radar, radio transmitters or other high energy generators. Thus, Completely Confined MDF protects against premature detonation.

Also, non-electrical firing does away with the need for a source of EMF, enabling you to save weight by eliminating batteries.

Now obtainable with a core load of 2 grains/ft. of either PETN or RDX and a detonation velocity of 6,500-7,000 meters/second, Completely Confined MDF offers you a fast, reliable impulse transmission medium.

A Du Pont Explosive Systems Specialist is available to help you with your ordnance design problems. Just write E. I. du Pont de Nemours & Co. (Inc.), 2446 Nemours Building, Wilmington 98, Delaware.

DU PONT REG. U.S. PAT. OFF. **WEAPON SYSTEMS SPECIALTIES**

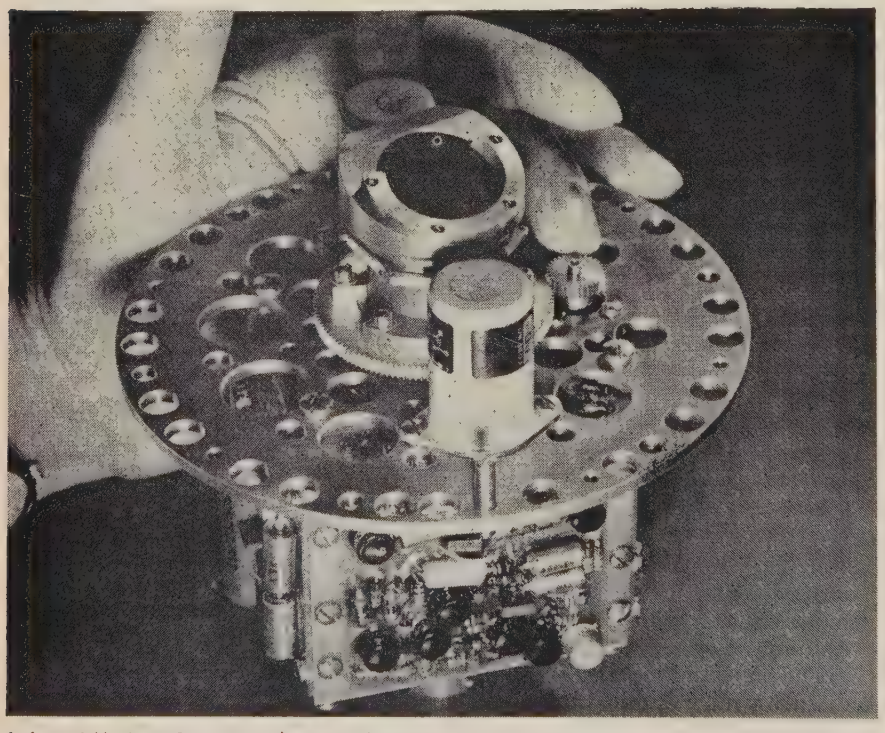
BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

No. 131 on Reader Service Card

Bristol choppers help first U.S. Astronaut maneuver space capsule

Four Bristol Syncroverter* choppers formed a vital part of the infrared horizon sensors manufactured by Barnes Engineering Company, Stamford, Conn., and carried aloft in NASA's MERCURY capsule by the first U.S. astronaut to reach outer space.

The Bristol choppers function as sensitive phase detectors in the sensors as they establish a horizontal reference plane for the vehicle.



Infrared Horizon Sensor undergoes rigorous optical, mechanical, and electrical checks at Barnes Engineering Co. One Bristol chopper is located in foreground, in front of gear.

Bristol Syncroverter* choppers, noted for low noise, long life and high reliability, are finding a vital place in more and more missile guidance systems, as well as in analog computers, d-c amplifiers, and test equipment for industrial applications. More than 200 models available. Write for complete details.

The Bristol Company, Aircraft Equipment Division,
150 Bristol Road, Waterbury 20, Conn.
A Subsidiary of American Chain & Cable Company, Inc.

*T.M. Reg. U.S. Pat. Off. 1.4

ACCO

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FILLER VALVE has leakproof design

A miniaturized filler valve for cryogenic, pneumatic, and hydraulic applications is being produced by **Airborne Research & Development Corp., Dept. S/A, 7530 San Fernando Rd., Sun Valley, Calif.**

The valve is said to feature an unusual leakproof design. Its female portion weighs 4 oz including dust cover, while the male half weighs 2 oz with cover. Its operating pressure is 0-200 psig, and its temperature range is —420 to 260 deg F. The ground (female) half incorporates an insulating sleeve and an annular air space as a thermal barrier. The valve can be supplied in a wide range of fittings on a basis of 30 days delivery ARPO.

No. 300 on Reader Service Card

SOLENOID for rotary switches

A solenoid originally designed to operate rotary switches in high power missile and rocket circuits is now being applied to the specific requirements of military and commercial manufacturers by **Singer-Bridgeport Div. of Singer Manufacturing Co., Dept. S/A, 915 Pembroke St., Bridgeport 8, Conn.**

The manufacturer states that the solenoid action, being a pure rotation of a balanced rotor, requires no linkages to convert linear to rotary motion, and therefore is inherently resistant to mechanical environments such as axial vibration and shock.

No. 301 on Reader Service Card

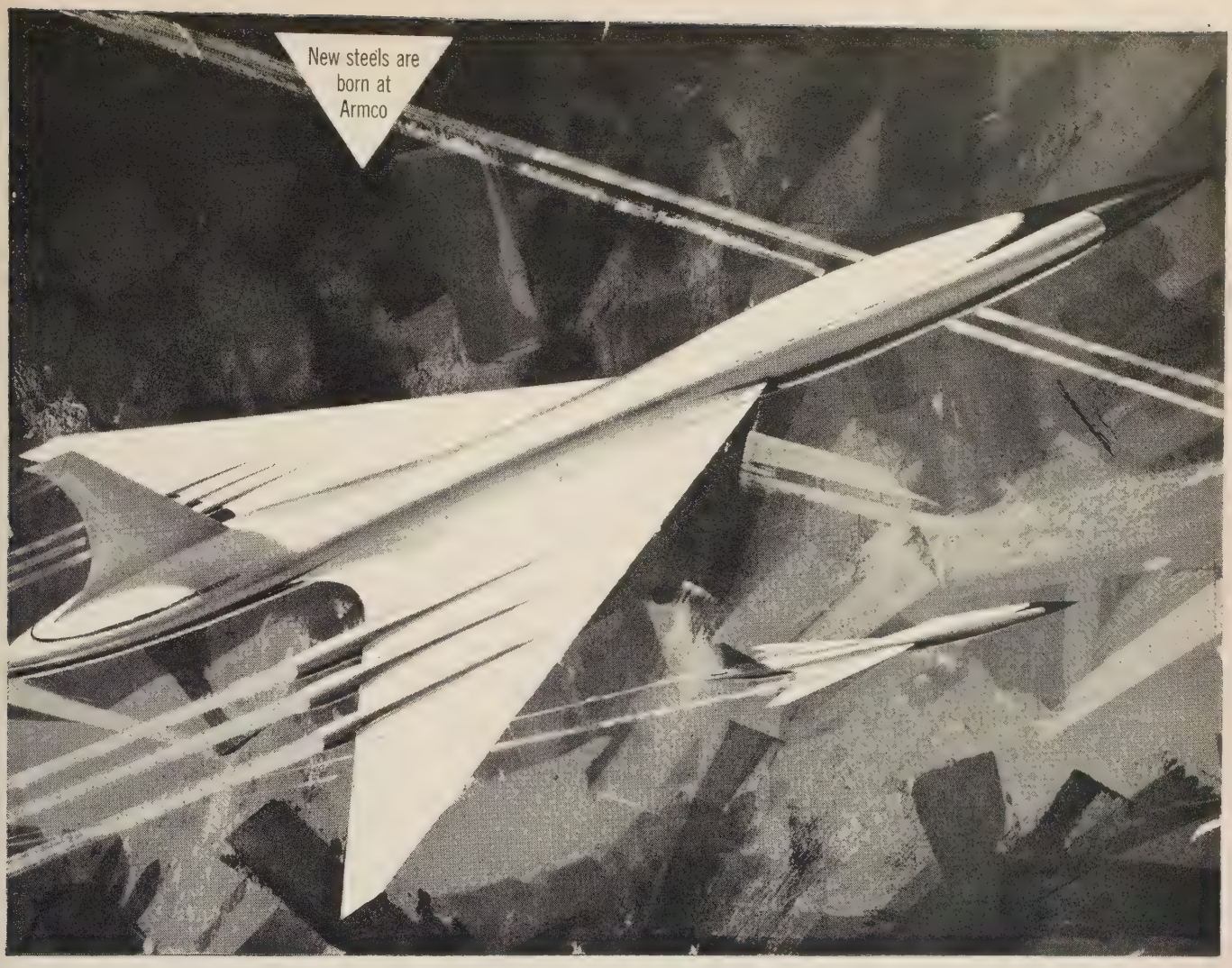
CARTRIDGE for fluid systems

A sub-miniature vane pump cartridge from **Vickers, Inc., Div., Sperry Rand Corp., Dept. S/A, Detroit 32, Mich.,** is said to offer unusually small size and flexibility of integration into many types of fluid system.

The unit measures only ¾ in. in diameter. Typical applications include circulation of fluids for cooling electronic equipment, low-power source for small-scale hydraulic systems, pumping fuel for small engines (under 100 hp), transferring liquid for gaseous fluids, and lubrication of remote and/or compact mechanical systems. Weighing only 1 oz, the cartridge delivers 0.1 to 1.3 gpm at pressures from 50 to 1500 psi, the manufacturer reports. It has a displacement of 0.003 to 0.013 cu. in. per revolution, and a speed range of 8000 to 26,000 rpm. Operating life is up to 1000 hr. It can be integrated with mechanical and servo valves, engine fuel controls, or any basic system where space is at a premium.

No. 302 on Reader Service Card

No. 132 on Reader Service Card



Armco PH 15-7 Mo Stainless Steel Helps Clear Way for Mach 3 Transports

Many of the formidable barriers to production of Mach 3 jet transports are eliminated by Armco's Precipitation-Hardening Stainless Steel—PH 15-7 Mo.

It combines the necessary characteristics for such critical use—high strength-weight ratios, useful high temperature properties, good corrosion resistance, producibility and economy.

Extensive use of Armco PH 15-7 Mo in the B-70 has led to development of cost-cutting techniques for production of PH 15-7 Mo parts. In addition, valuable data on critical properties have been accumulated. Produced in practically all commercial forms—foil, sheets, strip, plate, bars, wire, extrusions and forging billets, Armco PH 15-7 Mo is used in airframe, powerplant and accessories.

Stainless Steel

For Light-Weight Strength, Durability and Economy.

Let us send you useful data on the properties and fabrication of this special Armco Stainless Steel.

Armco Division, Armco Steel Corporation, 2601 Curtis St., Middletown, Ohio.

ARMCO

Armco Division

No. 133 on Reader Service Card

Is Your Oxygen Breathing System As Good As It Can Be?

As a pioneer in the research, development and manufacturing of oxygen breathing systems in both the medical and aviation fields, Puritan has accumulated unique experience and know-how that bear precisely on the problems you face today. For a new installation or improving your present oxygen system, your inquiry would be welcomed by Puritan's R & D.

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1703 McGee Street • Kansas City 8, Mo.
A subsidiary of PURITAN COMPRESSED GAS CORPORATION

BREATHING LIFE INTO AIR AND SPACE TRAVEL

No. 134 on Reader Service Card

PRESSURE SWITCHES offer improved accuracy

A new line of diaphragm pressure switches from **Barksdale Valves, Dept. S/A, P.O. Box 206, Palos Verdes Estates, Calif.**, is reported to offer improved accuracy, reduced cost, and higher proof pressures.

Accuracy of ±0.5 per cent is guaranteed, and ±0.2 per cent accuracy is available upon special request. Proof pressures to 600 psi and adjustable ranges from vacuum to 400 psi are available. The manufacturer reports that employment of the erector set technique—a standard body to which interchangeable components such as contact elements, capsules, terminal block housings, explosion proof housings, etc., may be attached—permits use of cost cutting mass production methods and allows wide choice in specifications.

No. 303 on Reader Service Card

INSULATION in flexible form

A new, flexible form of Min-K insulation has been announced by **Johns-Manville, Dept. S/A, 22 E. 40th St., New York 16, N. Y.**

Min-K is described by the manufacturer as unique among insulating materials in that its thermal conductivity is less than the molecular conductivity of still air, traditionally considered the lowest possible, and is recommended for missile and rocket applications. Flexible Min-K is said to wrap easily round cylinders, cones, or more involved shapes. In tape form it can be used for spiral winding on duct or pipe.

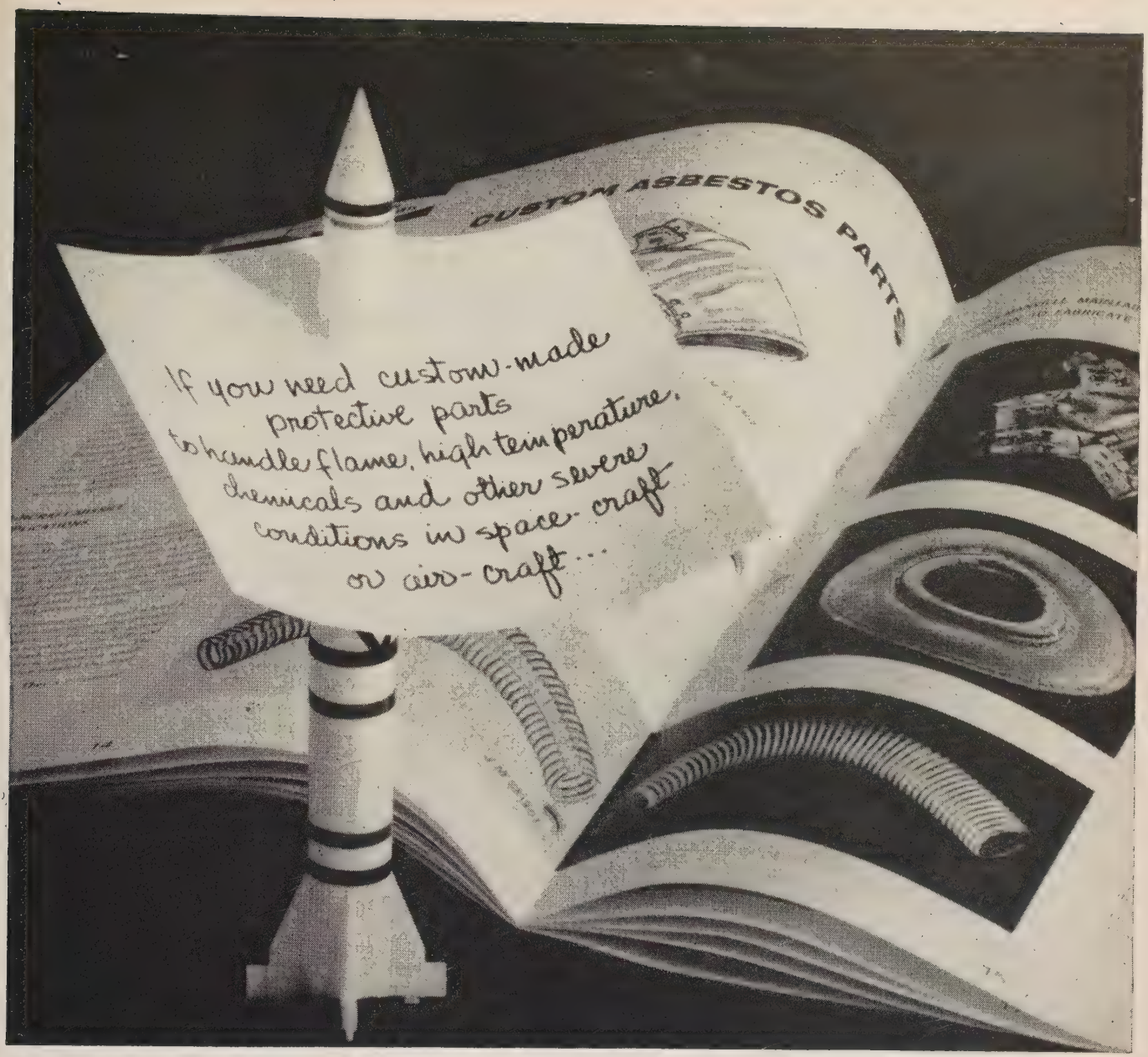
No. 304 on Reader Service Card

POWER PACKAGE for aerospace applications

Development of a lightweight hydraulic power package for aerospace and commercial aviation applications has been announced by **Hydro-Aire Div. of Crane Co., Dept. S/A, 3000 Winona Ave., Burbank, Calif.** The power package is said to achieve overall efficiencies as high as 64 per cent.

Incorporating an integrated pump-motor design, the unit weighs 4 lbs and measures about 4 in. high, 4 in. wide, and 7 in. long. Its integral design saves weight by employing a common shaft and bearing arrangement, according to the manufacturer. It consists of a fixed displacement pump driven by a DC motor operating at a nominal speed of 12,000 rpm. Rated delivery of the pump is 0.34 gpm minimum at 3250 psig over a voltage range of 25.5 to 30 V DC. The unit provides a radio noise filter per MIL-I-26600.

No. 305 on Reader Service Card


CUSTOM ASBESTOS PARTS
If you need custom-made protective parts to handle flame, high temperature, chemicals and other severe conditions in space-craft or air-craft...

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The Johns-Manville Custom Asbestos Parts group specializes in fabricating units to safeguard against flame and heat...where durability, flexibility and strength are required.

These ready-to-install Custom Asbestos Parts can be made up from asbestos cloth, tadpole tape, metal mesh or metal sheet...in whatever combination your design conditions require. Surface treatments of the asbestos fabrics include flameproof Neoprene–base compound, Silicone cements and rubbers, Du Pont Teflon, Viton, and aluminum. Assembly can involve cementing, braiding, weaving, stitching or oven curing.

The made-to-order protection of J-M Custom Asbestos Parts takes the hazards out of "hot-spots." Each is especially designed to handle its specific job. The examples you see on this page are only a few of the parts now serving in missiles or aircraft. The full story of Custom Asbestos Parts is in J-M's new 28-page booklet, which also describes the entire range of J-M Packings, Gaskets, Textiles and Friction Materials for air and space craft.

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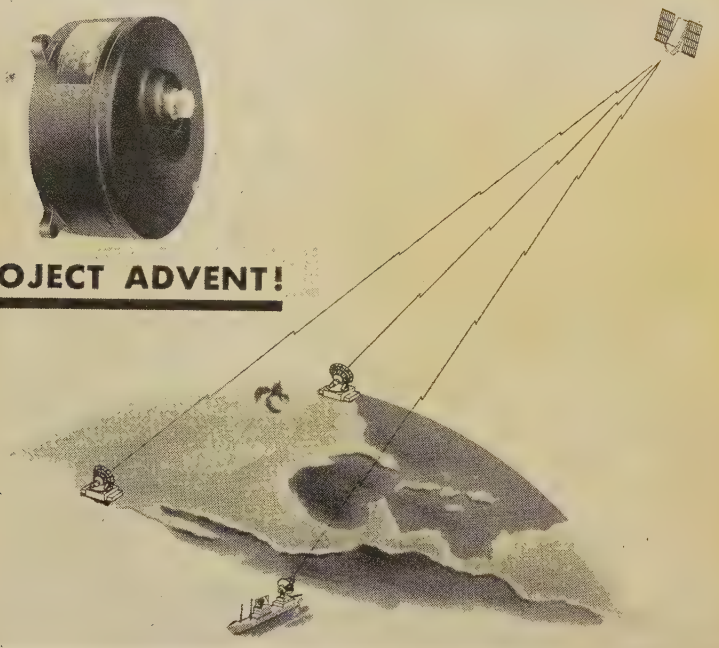
JOHNS-MANVILLE JM

No. 135 on Reader Service Card

ENGINEERING
REPORT
ON BENDIX COMPONENTS

SELECTED FOR

PROJECT ADVENT!



BENDIX REACTION WHEEL FOR SATELLITE CONTROL AND STABILIZATION

Precision reaction wheels developed at Bendix meet requirements for attitude control of space vehicles and satellites. For example, these wheels will be used for Project ADVENT—advanced Army research program which will use satellites as relay stations for global communications.

Since reaction torque is directly proportional to applied voltage, the reaction wheel provides a means for proportional control of vehicle attitude. An integral tachometer senses wheel speed and direction of rotation.

Several wheel configurations are now available, and the basic design concept offers flexibility to meet still broader requirements. Individual wheels can be tailored to specific voltage, torque, inertia, and momentum storage requirements.

ADVANTAGES AND FEATURES: Minimum weight and power • Brushless motor and tachometer • Low friction • Flexible design • Consistent performance over environmental range

PREVIEW LATEST SENSING, STABILIZATION, AND CONTROL DEVICES FOR SPACE SYSTEMS AT OUR WESCON BOOTH 2301-03.

Eclipse-Pioneer Division
Teterboro, N. J.

THE Bendix CORPORATION

District Offices: Burbank, and San Francisco, Calif.; Seattle, Wash.; Dayton, Ohio; and Washington, D.C.
Export Sales & Service: Bendix International, 205 E. 42nd St., New York 17, N.Y.

No. 136 on Reader Service Card

ELECTRIC SWITCH meets military specs

A new electric switch, designed to meet Mil-S-6743 for drawings MS-25342 and MS25343, has been announced by **General Electric Co., Appliance Control Dept., Dept. S/A, Morrison, Ill.**

The switch is a double-break, momentary contact type, and is return-spring operated. Its case, cover, and pushbutton are made of molded diallyll phthalate plastic to meet military requirements. It has been designed for a minimum operating life of 100,000 cycles, and will operate satisfactorily in ambient temperatures from −70 to 190 deg C, the manufacturer reports. Designed for operation at 28 V DC or 115 V, 400 cycles AC, the switch has a resistive or inductive current capacity of 10 amps and a motor current capacity of 6 amps. It is available with hook-type solder lug terminals either out the side or out the ends of the case.

No. 306 on Reader Service Card

HYDRAULIC PUMP for aircraft, missiles

A new hydraulic pump for aircraft and missiles has been announced by the **Kellogg Div., American Brake Shoe Co., Dept. S/A, 530 Fifth Ave., New York 36, N. Y.**

Known as the AP2V, it delivers approximately 10 gal per min at 6000 rpm and 3000 psi, the manufacturer reports, with a maximum displacement of 0.40 cu in. per revolution. It weighs 6.5 lbs. The AP2V is a single-stage, variable-volume, cam-actuated pump with pressure compensator control, Its response characteristics meet and exceed those required by MIL-P-25868 and MIL-P-19692, and its volumetric efficiency is said to be over 95 per cent through a pressure range up to 3000 psi.

No. 307 on Reader Service Card

METAL SEAL handles hydraulic pressure

An all-metal seal from **B. F. Goodrich Aviation Products, 500 S. Main St., Dept. S/A, Akron, Ohio,** is reported to handle hydraulic pressures under the adverse conditions encountered by missiles and supersonic aircraft.

Made of high-temperature alloy steels, it has performed satisfactorily at temperatures up to 530 deg F and at pressures up to 6000 psi, according to the manufacturer. It does not require close tolerances, is self-compensating for reasonable misalignment and side loads, and has an extremely low break-out force, Goodrich reports. It has been tested with reciprocating and rotary motions, and is also available for static applications.

No. 308 on Reader Service Card

SOLAR SENSORS
for space environment

Solar sensors, designed for operation in a space environment, are offered by **Ball Brothers Research Corp., Dept. S/A, Boulder Industrial Park, Boulder, Colo.**

The photoelectric sensors are intended primarily for high-performance servo control of rocket and satellite-borne sun trackers, the manufacturer reports. They can be furnished with various angular characteristics for coarse servo control, fine servo control, spin detection, and aspect determination. The sensor assemblies weigh about 10 grams each.

No. 309 on Reader Service Card

ACCELEROMETER
has integral stud

A microminiature accelerometer from **Endevco Corp., Dept. S/A, 161 E. California Blvd., Pasadena, Calif.**, weighs only 1.3 grams, is ⅜ in. hex and ½ in. high, and includes an integral 6-32 stud.

The design provides mechanical isolation from noise-producing cable stress, the manufacturer reports. Voltage sensitivity with 180 pf external capacity is 5.0 pk-mv/pk-g nominal; resonance frequency is 30 Kcps nominal/cross-axis sensitivity is 5 per cent maximum; temperature range is —65 to 350 deg F with 15 per cent or less nominal sensitivity deviation.

No. 310 on Reader Service Card

CLUTCH/BRAKE
is matched with servo pot

A miniature electro-magnetic clutch/brake has been specifically designed for factory mating with a customer specified precision servo potentionmeter by **Dynamic Instrument Corp., Dept. S/A, 59 New York Ave., Westbury, N. Y.**

Called a wafer clutch/brake because of its short length, the new unit is said to dramatically reduce silhouette length of the pot/clutch/brake assembly. The manufacturer also reports that it eliminates backlash, shaft misalignment, and end play, and the conventional added mass from the rotating coupling parts which subject the assembly to shock and acceleration forces associated with high G loads. Its specifications are: power consumption, 2 W at 24 V DC; dielectric test, 500 V AC RMS 60 cycles from terminal to case; insulation resistance, 500 megohms (minimum) at 500 V DC; operating voltage, 24-28 V DC; minimum torques, clutch—10 in./oz, brake—6 in./oz; response time at 24 V DC, 8 millisec; weight, 1.3 oz.

No. 311 on Reader Service Card

TUBING
is heat-shrinkable

Development of a new type of tubing that shrinks to form a tight mechanical bond within 7 sec after application of 135 deg C of heat has been announced by **Alpha Wire Corp., Dept. S/A, 200 Varick St., New York 14, N. Y.**

Alphlex Shrinkable Tubing is described as an irradiated, flame-retardant, thermally stable, modified polyolefin base product, suitable for insulation and a variety of other uses. It is manufactured in an expanded fom, so that it can be easily slipped over wire and cables, hosing, terminals, or conduit. When heat is applied, it shrinks to a predetermined diameter, with longitudinal shrinkage of less than 10 per cent.

No. 312 on Reader Service Card

MOTOR GENERATOR
is highly stable

This 60-cycle, 115-volt generator for ground support equipment, industrial control, and automation applications, has been developed by the **Transcoil Div., Daystrom, Inc., Dept. S/A, Worcester, Penna.** Availability in the size 11 frame size permits substantial space saving in servo packages, according to the manufacturer. The unit is 3 in. long and 1.062 in. in diameter.

General specifications include a scale factor of 2.7 volts per 1000 rpm, signal to noise ratio of 100, and an input power of 3.5 watts. Designs are available from 26 to 115 volts.

No. 313 on Reader Service Card

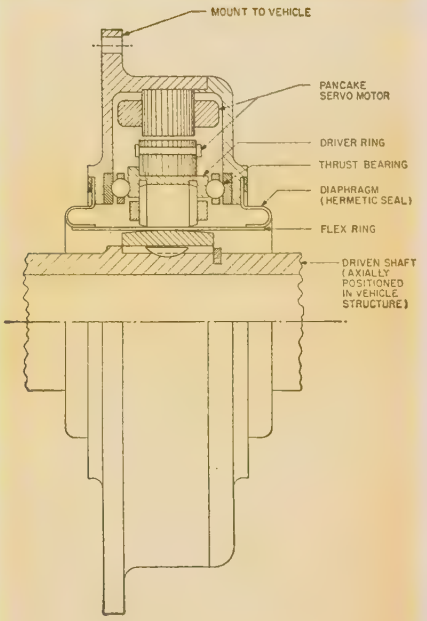
EXPANSION JOINTS
for off-the-shelf delivery

Off-the-shelf delivery of stainless steel (Type 321) high-precision bellows-type expansion joints to fit standard pipe sizes from 3 in. to 72 in. nominal diameter has been announced by **Pathway Bellows, Inc., Dept. S/A, 999 Industrial Place, El Cajon, Calif.**

The standard bellows for immediate delivery has 5 or 8 convolutions, and operates in three pressure ranges: 0 to 50 psi, 50 to 150 psi, and 150 to 300 psi. (Exceptions are 32-72 in., 300 psi, and 42-72 in., 150 psi, which must be specially engineered.) Standard maximum operating temperature is 450 deg F. End fittings are schedule 40 pipe weld nipples. Non-standard Pathway bellows can be designed and manufactured to meet operating pressures from high vacuum to 5000 psi according to diameter, and temperatures from —300 to 1500 deg F.

No. 314 on Reader Service Card

ENGINEERING REPORT
ON OTHER BENDIX COMPONENT PACKAGES



CYCLO-SINE

Hermetically-sealed drive for space applications

The Bendix® Cyclo-Sine Drive provides an absolute, hermetically-sealed actuator for varied space applications. Operating through a flexible ring, the drive offers infinite resolution and irreversibility for general-purpose and precision servo devices.

OUTSTANDING CHARACTERISTICS:

5:1 weight advantage over conventional drives • Up to 20,000:1 speed differential • No backlash • Infinite resolution

Manufacturers of

GYROS • ROTATING COMPONENTS
RADAR DEVICES • INSTRUMENTATION
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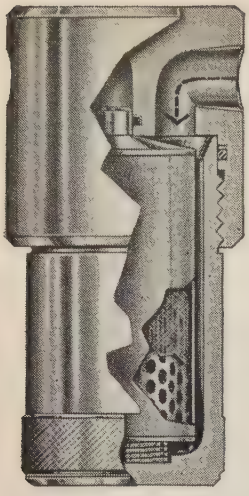

Looking for a standard microfilter rated up to (or above) 10,000 psi?

LOOK INTO THIS FD DESIGN**

Note (1) flow contoured inlet; (2) eccentric location of outlet; (3) deflection surface that guides stream around element. Result? At 10,000 psi inlet pressure, ½-inch filter passes 1000 SCFM (nitrogen at 70°F) without pushing △P above 50 psi. Dynaloy* C sintered stainless steel element removes 98% of all 10-micron particles (finer or coarser elements also supplied). Unit handles fluids from —320°F to +400°F. Available in ¼-inch to 1-inch sizes. Minimum burst pressure 36,000 psi. For detail sheet, for brochure (D-5), please write.

*Trade name of FLUID DYNAMICS Incorporated **Pat. Applied for

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Dept. SA-8, 90 West St., New York 6, N. Y.

No. 193 on Reader Service Card

PHENOLIC TUBING withstands high forces

Grade HY 488 high-strength paper base phenolic tubing withstands high compression and burst forces applied radially with only a small sacrifice in axial strength. According to **Micarta Div., Westinghouse Electric Corp., Dept. S/A, Hampton, S.C.**, axial flexural strength is 19,650 psi, axial tensile strength is 12,025 psi, and ultimate fiber tensile strength is 33,750 psi.

The tubing is available in lengths up to 80 inches, internal diameters of ⅛ in. to 48 in., and in wall thicknesses from 1/32 in. to one inch. Typical applications where high "hoop strength" is important are textile bobbins, rocket flare tubes, and fuse tubes.

No. 315 on Reader Service Card

AIRBORNE PARTICLE MONITOR has dilution system

Adding an air-dilution system to the Model PC200A airborne particle monitor provided a unit which can describe the spectrum of particles in air ranging from clean to polluted atmospheres. Available from **Royco Instruments, Inc., Dept. S/A, 440 Olive St., Palo Alto, Calif.**, the dilution system provides a continuously variable addition of filtered air from 0 to 200 cc per min, giving dilution ratios from 0 to 50:1.

Fifteen sub-ranges of particles from 0.32 to 8 microns can be examined and indicated on decade registers, as well as being recorded. Particle concentrations to 7340 per min can be counted, with a normal 100-cc per min sample. In the programed mode, monitoring ranges of 0.3, 1, 3, or 10 min are available.

No. 316 on Reader Service Card

Don't spoil it- KROIL it!

Don't ruin a valuable piece of equipment merely because some part is rusted tight. Apply *KROIL*, the amazing new chemical lubricant that creeps into millionth inch spaces (proved by laboratory tests), **dissolves rust, supplies necessary lubrication and . . .**

Loosens Frozen Parts

18,000 of America's leading plants can't be wrong. They have used KROIL for ten years and depend on it to save expensive labor and valuable parts. They say: "Kroil loosened bushings after a 12-ton press had failed" . . . "on repairing heat treat trolleys formerly destroyed every nut. Now Kroil saves them all, and time, too."

You too can get these results. Try KROIL on money-back basis. Gallon, $4.35; with Kroiler squirt gun, $5.25, f. o. b. factory.

Ask for GENIUS AT WORK—a free publication full of ideas for maintenance men.

KANO LABS. 1097 Thompson Lane Nashville 11, Tennessee

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35G VIBRATION RELAY

A SENSITIVE RELAY WITH 0.2 INCH GRID SPACED TERMINALS

SPECIFICATIONS:

Contact Arrangement: DPDT (2C)
Contact Rating: 3 amps resistive at 28VDC
Operating Power: 250 MW standard, 100 MW special
Vibration: 35G's to 3000 CPS
Shock: 100G's standard, 150G's special
Dielectric Strength: 1000V RMS, 750V RMS between open contacts
Ambient Temperature Range: —65°C to +125°C
Terminals: plug-in pins, solder hooks, 3-inch leads
Mounting: a variety of popular bracket and stud arrangements
Dimensions: 0.875 inches high, by 0.800 inches wide, by 0.396 inches thick
Weight: 0.6 ounces maximum

VR SERIES RELAY

ELGIN advance RELAYS

THE ELECTRONICS DIVISION OF ELGIN NATIONAL WATCH COMPANY 2435 NORTH NAOMI STREET, BURBANK, CALIFORNIA

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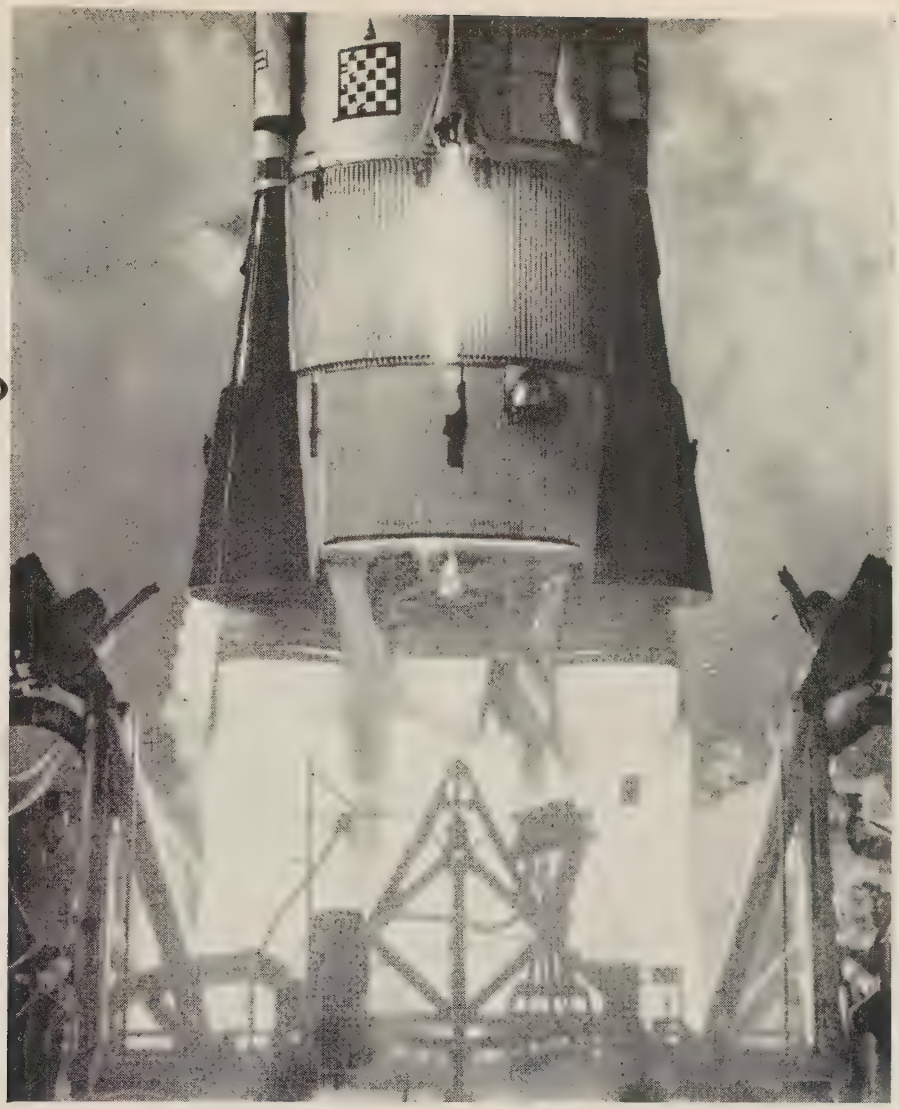
another advance in vibration/shock/noise control



"Soft" mounting will get your project off the ground more reliably

Here are the hard facts:

■ Soft mounting—or the use of engineered protective suspensions—has become the preferred method for boosting the reliability of aerospace equipment.

As applied by experienced Lord engineers, this technique provides an optimized system for protection against severe vibration/shock/noise environments. Here's why:

Soft mounting reduces the effects of dynamic disturbances to safe, predictable levels. Isolation efficiencies are compatible with equipment response characteristics.

Soft mounting can provide the performance versatility to control low, high or broad frequency vibration plus shock.

Soft mounting avoids direct attachment of the equipment to the structure where vibration levels are often an unknown factor.

Soft mounting combines damping and elasticity in an engineered package compatible with tight-space limitations.

Soft mounting ends the danger of local or unforeseen resonant responses causing damage or equipment malfunction.

Soft mounting offers cost and weight savings compared to ruggedization. "Beefing up" is avoided and lighter components can be used.

Soft mounting provides protection for storage, transport or in-flight environments.

Soft mounting has increased the reliability of equipment for such projects as Atlas, Titan, Polaris, Hawk, Centaur, Minuteman, Mercury, low-level B-52, X-15 and others.

Lord offers aerospace designers proved capabilities in the design, production and testing of soft mounting systems. A call to the nearest Lord Field Engineering Office or the Home Office, Erie, Pa. will put you in touch with the specialists in vibration/shock/noise control.

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KANSAS CITY, MO. · WEstport 1-0138
LOS ANGELES, CAL. · HOllywood 4-7593
NEW YORK, N.Y. (Paramus, N.J.)
New York City · BRyant 9-8042
Paramus, N. J. · Diamond 3-5333
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"In Canada · Railway & Power Engineering Corporation Limited

LORD MANUFACTURING COMPANY · ERIE, PA.

expressway for automatic all-weather landings

SPECO The Steel Products Engineering Division of Kelsey-Hayes is developing the radar antenna mounts for **Bell Aerosystem's** All-Weather Automatic Landing System. Designated AN/SPN-10 by the Navy, the system has been selected for use aboard the U.S.S. Enterprise and other nuclear powered carriers.

Since 1914, Speco has been a vital force in the nation's aviation and defense programs . . . and since 1949, has provided radar componentry for Titan, Hawk, Nike-Hercules, Nike-Zeus and many other guidance systems. For further information, write Speco Division, Kelsey-Hayes Co., Springfield, Ohio.

KELSEY HAYES COMPANY

Automotive, Aviation and Agricultural Parts
Hand Tools for Industry and Home

OPERATIONAL PLANTS: Detroit, Jackson and Romulus, Michigan; Los Angeles, California; Philadelphia, Pennsylvania; Springfield, Ohio; Utica, New York; Davenport, Iowa; Rockford, Illinois; Windsor and Woodstock, Ontario, Canada.

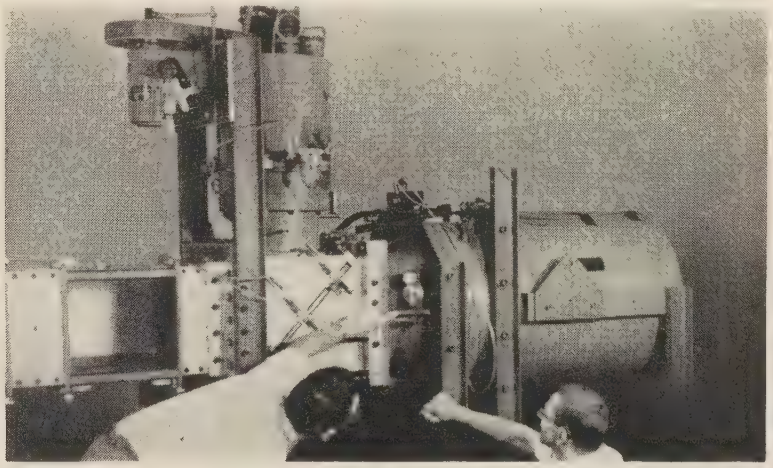
K H

No. 182 on Reader Service Card

TEST AND GROUND SUPPORT equipment preview

For details on equipment listed in this section, write in item number on Reader Service Card

SIREN-TYPE NOISE GENERATORS TEST ACOUSTIC FATIGUE



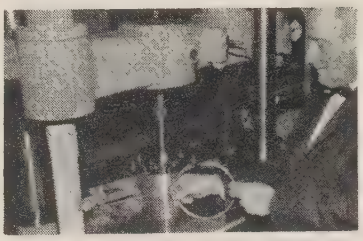
Based on the proven siren-type noise generator, the "Acousti-Dyne" acoustic noise generating systems are designed by American Measurement & Control, Inc., 240 Calvary St., Waltham 54, Mass., to produce high-intensity sound for research and proof testing involving acoustically induced fatigue on structures and components. The Model 825 generator can produce more than a 164-db sound pressure level in a one-square-foot test section (2500 W of acoustic power), the 830 can produce a 168-db sound pressure level (10,000 W), and the 835 can produce a 174-db sound pressure level (40,000 W). The frequency range extends from 50 to 10,000 cps. The sinusoidal acoustic output can be amplitude-modulated at frequencies up to 50 cps.

The 825 is a completely integrated unit mounted on a frame 12 ft long, four feet wide, and six feet high. It consists of a six-inch Acousti-Dyne siren and controls, a hydraulic power supply, and air compressor and aftercooler, a progressive-wave, or reverberant-type test section, and air ducting and controls. The 830 and 835 are 12-in. and 24-in. sirens for installation in large test cells. The rack-mounted control consoles for all three Acousti-Dyne units are similar. **86**

Navy Tester Hastens Development of Fiberglass Rocket-Motor Chambers

Lightweight fiberglass rocket motor chambers, reinforced with non-woven glass fibers (roving), are destined soon to become standard equipment for spacecraft. Such chambers may cost only a fourth as much and be up to three times as strong on a weight basis as present metal chambers.

This prediction comes from chemists at the Naval Ordnance Lab in Silver Spring, Md., who have developed a test device for studying fiberglass.

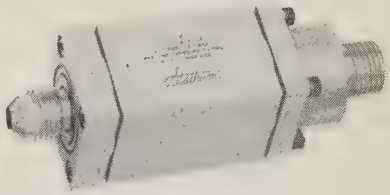


Called the "NOL Hydraulic Ring Tensile Tester," the new unit is essentially a pressure-tight housing in which fiberglass hoops are hydraulically ruptured. In many cases, the data so collected are directly applicable to the design of large rocket motors.

Thus far, tests have indicated that applying a chemical finish to glass fibers is an important factor in improving the tensile strength of a glass-reinforced plastic.

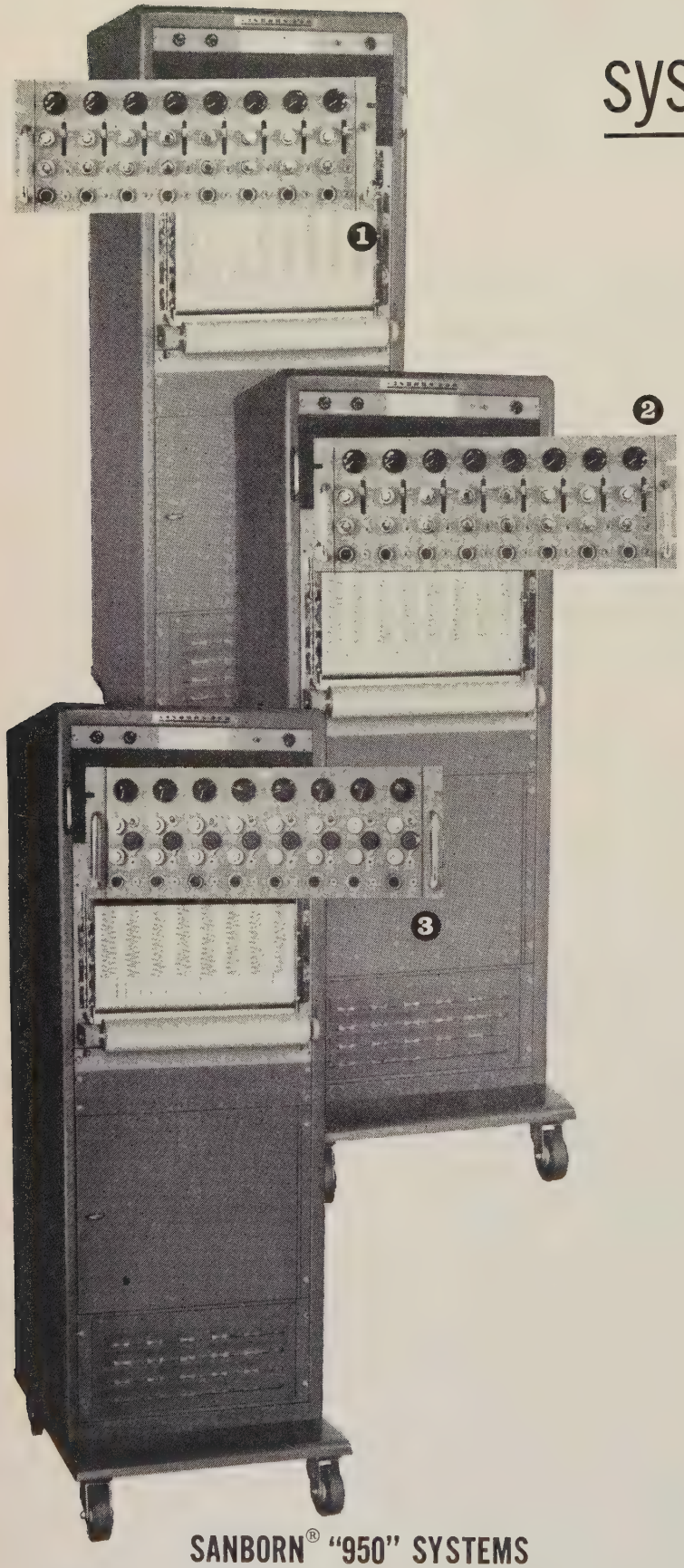
These data will ultimately be used to prepare specs for glass roving for reinforcing plastics.

Pressure Transducers for Many Ranges Operate at up to 600 deg F



The new P732 series of high-temperature gage and differential pressure transducers more accurately measure pressures over a wide variety of ranges and under extreme environmental conditions, claims Statham Instruments, Inc., 12041 W. Olympic Blvd., Los Angeles 64, Calif. Of rugged stainless steel construction, they are tem-

match system sensitivity to your recording application



When your recording application calls for 6 or 8 direct writing, general purpose channels with identical sensitivity and input electronics, Sanborn "950" design provides a highly useful, economical answer in the precise sensitivity range you need. Choices include systems with:

1 **HIGH GAIN AMPLIFICATION** . . . 6 or 8 transistorized channels with floating and guarded inputs, 100,000 ohms resistance on all ranges, 10 to 2000 uv/div sensitivity. System response DC to 100 cps within 3 db at 10 div peak-to-peak amplitude. Common mode performance ±200 volts, max., rejection 140 db min. at DC. High gain stability, max. non-linearity 0.5%, low noise and drift. All channels have range, gain, function, position and galvanometer frequency compensation controls.

2 **MEDIUM GAIN AMPLIFICATION** . . . 6 or 8 transistorized channels with floating and guarded inputs; ½ meg. resistance on mv ranges, 1 meg. on volt ranges; sensitivity 0.5 to 20 mv/div and volts/10 div. System response DC to 150 cps within 3 db at 10 div peak-to-peak amplitude. Common mode voltage ±500 volts, max., rejection 140 db min. at DC. Same controls as High Gain amplifier.

3 **LOW GAIN AMPLIFICATION** . . . 6 or 8 channels, balanced to ground inputs 5 meg. each side; tube and transistor circuitry; sensitivity 10 to 500 mv/div and 1 to 10 volts/div. System response same as Medium Gain system. Common mode performance ±2.5 volts and 34 db min. rejection on most sensitive range. Amplifier available with or without Calibrated Zero Suppression.

All "950" systems have 350-style 6- or 8-channel flush-front, heated stylus recorder, using Sanborn rectangular-coordinate Permapaper.® Nine chart speeds, timer/marker stylus, built-in paper take-up. Systems housed in 63⅜" high mobile cabinets; amplifier and recorder occupy only 24½" of panel space. For complete descriptive literature and application assistance, call your Sanborn Industrial Sales-Engineering Representative; offices throughout the U. S., Canada and foreign countries.

SANBORN® "950" SYSTEMS

Dynamic demonstrations of 950 Systems and other Sanborn oscillographic recording equipment at WESCON, Aug. 22-25 Booths 2014-2016

INDUSTRIAL DIVISION
SANBORN COMPANY
175 Wyman St., Waltham 54, Mass.

No. 183 on Reader Service Card

perature-compensated for continuous operation at up to 600 deg F. The ambient temperature limits are —320 and 650 deg F. Pressure ranges on the gage and uni-directional differential models extend from 0-2 psi through 0-5000 psi. The bi-directional differential model operates from ±1 through ±100 psi.

Among the features claimed for the P732 are:

- improved temperature stability through the use of Statham's new zero-length, dimensionless unbonded strain gage;
- high overload characteristics, providing safe, long-time operation;
- lower sensitivity to static and vibratory accelerations;
- combined non-linearity and hysteresis of less than ±0.75 in both high and low pressure ranges.

87

equipment in brief

TEMPERATURE PROBE for measurement in gases

Temperature probes have been developed by **United Sensor & Control Corp., Dept. S/A, P.O. Box 149, Glastonbury, Conn.**, for maximum accuracy of measurement in gases at velocities of 100 to 2000 ft/sec and temperatures up to 500 deg F. They are designated Type TD.

Thermocouple elements can be furnished in standard Iron-constantan, Copper-constantan, and Chromel-Alumel wires. The elements are coiled to expose maximum surface to the gas to eliminate conduction errors. Bleed slot area is varied to give maximum accuracy at the mean flow velocity in which the probe is to be used.

No. 455 on Reader Service Card

HYDRAULIC VALVE operates on AC and DC

A solenoid-operated hydraulic valve for ground support equipment or other critical control applications is available from **Parker Aircraft Co., Dept. S/A, 5827 W. Century Blvd., Los Angeles 45, Calif.** It operates on both 115 V AC and 28 V DC without adjustment or coil changes, the manufacturer reports.

It is said to permit operation on regular 60-cycle line current, and on emergency or portable battery power at a cost as low as single voltage valves. The valve assembly consists of a solenoid-operated pilot valve and a heavy-duty slave valve designed for sub-plate mounting. Various flow sizes are available. All components are designed for operation at nominal system pressures up to 5000 psi, and have a life in excess of 5 million cycles. Special valves for 500-cycle AC can be supplied.

No. 456 on Reader Service Card

METERING DEVICE indicates hours of operation

The Time Totalizer, a metering unit that indicates accumulated hours of operation, is produced by **Leland Airborne Products Div. of American Machine & Foundry Co., Dept. S/A, 261 Madison Ave., New York 16, N. Y.** The manufacturer believes that the device will be of prime value in ground and maintenance of ground and airborne electronic gear.

The Time Totalizer is a mercury coulometer, operated by an integral electrical network which compensates for temperature differences and for supply voltage variations. AC and DC models are available, both designed for full scale ranges of 1000 hrs. The device is said to offer ±6 per cent accuracy over its full temperature (—30 to 160 deg F), voltage and frequency ranges, and great resistance to vibration and shock. It is priced at $12 to $15, depending on quantities ordered.

No. 457 on Reader Service Card

TESTER for liquid gage checkout

Entire liquid quantity gage systems can be tested and calibrated with the self-contained, portable, "Quan-Test", manufactured by **Consolidated Airborne Systems, Inc., Dept. S/A, 900 Third Ave., New Hyde Park, N. Y.**

The Model TF-20 "Quan-Test" is said to be the only servo-operated tester of its kind, and to sharply reduce testing time by making possible in-place or bench inspection and checkout of probes, indicators, and cables in capacitance-type gage systems measuring quantity of fuel, oil, liquid oxygen, and other fluids.

No. 458 on Reader Service Card

BULOVA
DC
REFERENCE
SOURCE

In this Bulova double stage Zener model, regulation is accomplished by controlling the base voltage of a series power transistor (Q_1). With the first Zener across input, the voltage changes of unregulated source are attenuated. The second Zener acts as a voltage reference for feedback amplifier stage (Q_3).

The Zener control current automatically changes with output voltage so that the control voltage amplifier absorbs the difference. Reduced number of components achieve optimum performance with high reliability using thoroughly silicon solid state devices. The small size 1½" square by 1¾", permits this unit to fit in any system which requires a DC reference source.

For additional data on frequency controlled components, write

Bulova Electronics,
Woodside 77, N. Y.

BULOVA
ELECTRONICS
DIVISION

No. 184 on Reader Service Card

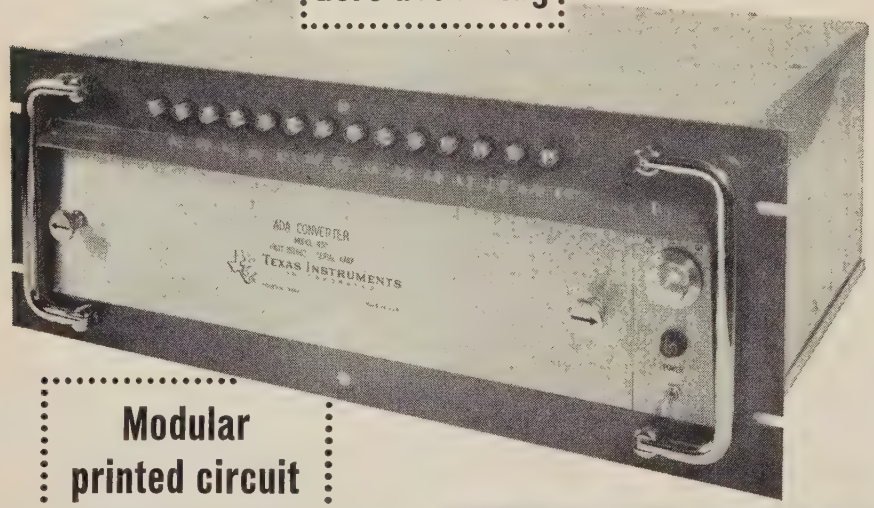
NEW FROM TI

HIGH SPEED A·D·A CONVERTER

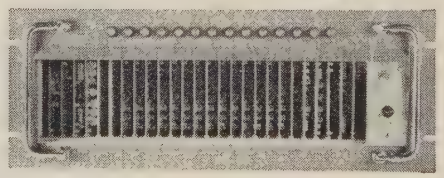
1.5 micro-seconds per bit

Automatic zero balancing

All solid state circuitry



Modular printed circuit construction



Texas Instruments Model 430 Analog-Digital-Analog Converter, a high speed, all solid state instrument, combines an exceptionally fast conversion time with high accuracy and wide dynamic range. The basic speed (analog-to-digital) is 1.5 microseconds per bit plus 4.5 microseconds per conversion; accuracy is ±0.1% of the input voltage or ±2 mv, whichever is greater. Dynamic range of the instrument is above 80 db if the full complement of 14 bits (including sign) is specified. Fourteen bit conversions are made at rates up to 35 kc/sec; any number of bits (up to 14) may be employed with correspondingly higher conversion rates.

Digital outputs are available in parallel form at the completion of the cycle. The instrument is equipped for remote switching between analog-digital and digital-analog modes. An automatic zero balancing system using one full conversion cycle per millisecond has been developed to cancel errors due to d-c drift within the analog portions of the circuitry. This converter is one of several data handling products designed and manufactured by Texas Instruments. It can be modified for many digital data handling applications. Write for complete information.

APPARATUS DIVISION
PLANTS IN HOUSTON AND DALLAS, TEXAS

TEXAS INSTRUMENTS
INCORPORATED
3609 BUFFALO SPEEDWAY
P. O. BOX 6027 HOUSTON 6, TEXAS

432

TAPE HANDLER
has speed of 500 ch/sec

A high-speed, uni-directional tape handler has been announced by the **Digitronics Corp., Dept. S/A, Albertson, N. Y.** Designated the Dykor Model 4544, it is designed to function with the Dykor 3500 photoelectric tape reader.

The Model 4544 handles 500 ft of 5- to 8-level tape interchangeably, at speeds up to 500 characters per second, the manufacturer reports. To load, the tape is placed in the bin on the input side of the reader, and threaded through the reader onto a servo-controlled take-up spool. To unload, the side of the take-up spool is removed, and the tape is slipped off the 4-pin hub.

No. 317 on Reader Service Card

TRANSDUCER
for missile applications

A low range pressure transducer for missile applications, reported to be highly accurate, has been developed by **Consolidated Electrodynamics Corp., Dept. S/A, 360 Sierra Madre Villa, Pasadena, Calif.**, a Bell & Howell Co. subsidiary.

The Type 4-328 transducer is designed to operate in pressure ranges from 0-15 psi to 0-99 psi absolute. The manufacturer reports that a shunt calibration feature makes it easy for the system designer to provide complete calibration of his data handling system. The instrument's operable temperature range is from —100 to 300 deg F. Combined linearity and hyteresis i less than ±0.5 percent of full range output as measured from the best straight line through the calibration data. An output of 50 mv is intended to make the 4-328 particularly suitable for use with the latest data transmission and recording systems.

No. 318 on Reader Service Card

AIR CONDITIONER
holds control to ± 2 deg F

This air conditioner is designed to supply cooled or heated filtered air to radomes, huts, trailers, and other installations where extremely close temperature and humidity control are important. The Model HAC-1000 unit performs both heating and cooling says **Budd Electronics, Inc., Dept. S/A, 43-22 Queens St., Long Island City 1, N.Y.**

The HAC-1000 has a cooling capacity of 12,500 btu/hr. At low temperatures, a heater with a capacity of 3,413 btu/hr brings the air up to the desired temperature. The equipment is packaged in a fully enclosed structural aluminum cabinet which measures 30x28x26 in.

No. 319 on Reader Service Card

No. 185 on Reader Service Card

WIND TUNNEL DEVICES calibrate gas streams

Two new wind tunnel devices have been designed for accurate determination of stagnation pressures and heat transfer rates of high temperature gas streams by **Plasmadyne Corp., Dept. S/A, 3839 S. Main St., Santa Ana, Calif.**, a Giannini Scientific Corp. subsidiary.

The PT-12, a water cooled pitot tube, measures stagnation pressures downstream of the shock wave produced by a material test sample or aerodynamic model in the high temperature supersonic gas stream. It is designed for 15-sec maximum insertion in a 16,000 btu/lb gas stream, and precisely measures pressures from full vacuum to 100 psi, the manufacturer reports. The WCC-6, a water cooled calorimeter, makes calculations of stagnation-point heat transfer rates from differential temperature and flow volume measurements of water circulated through the hemispherical tip.

No. 320 on Reader Service Card

TEST STAND for plasma calibration

A plasma jet calibration test stand for determining specific enthalpy and total pressure of a plasma stream has been announced by **Plasmadyne Corp., Dept. S/A, 3839 S. Main St., Santa Ana, Calif.** Determination of precise heat flux rates is considered particularly important in analyzing material behavior under simulated hyperthermal conditions.

The test stand is to be used for preliminary screening of materials in re-entry studies, tests of hyperthermal-resistant materials used in rocket nozzle liners and nuclear reactors, and for controlled chemical reactions by introducing chemicals into the plasma stream.

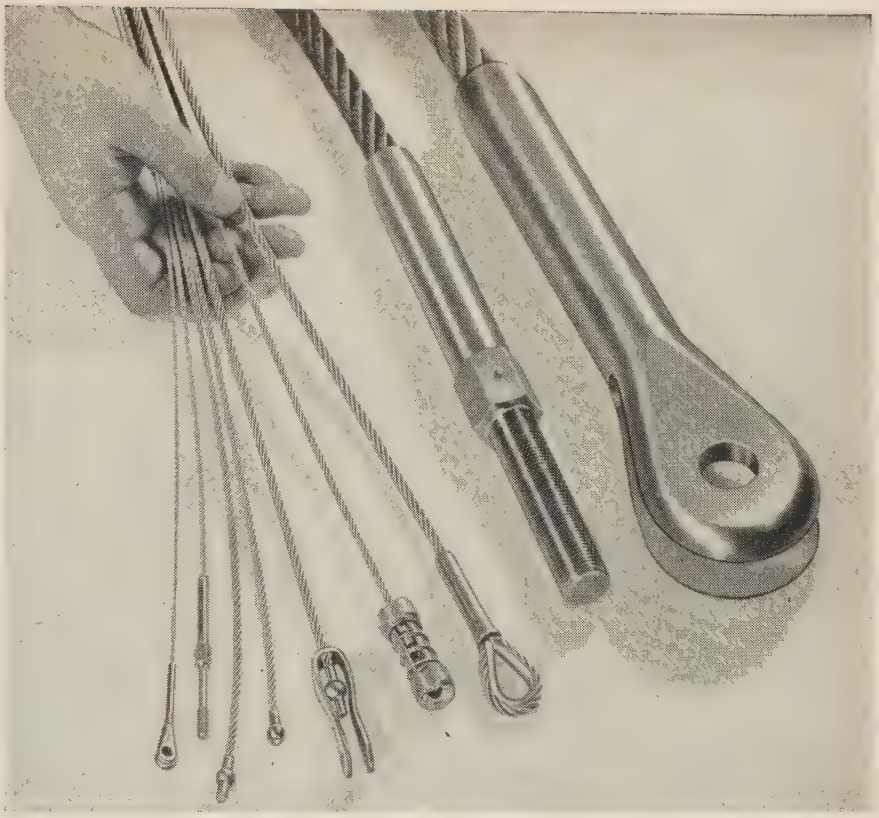
No. 321 on Reader Service Card

CHECKOUT UNIT for C-band radar beacons

A radar beacon checkout unit that measures 19 inches by 18 inches by 12 inches and weighs less than 60 pounds has been designed by **Astronautics, Inc., Dept. S/A, Melbourne, Fla.** Designated model RBCC-1, the test equipment is for multiple functions in relation to a C-Band beacon.

Included are the following parameters: threshold, power output, countdown and beacon delay and repeater if required. Comparable units are available for each of the various bands. The model is designed for mean operation at 5600 mc, but is available in ranges from 1 kmc to 12 kmc operation.

No. 322 on Reader Service Card



Tru-Loc Swaged Aircraft Fittings
guaranteed free from defects...

Tru-Loc aircraft fittings are guaranteed three ways—they conform to specified dimensions; they hold to the minimum rated breaking strengths of the cables to which they are swaged; and they are free from deformation, splits and internal cracks. With Tru-Loc swaged fittings you also get:

Widest range of sizes • Tru-Loc fittings are available for cables ranging from 1/16" to 2 1/2" diameters.

Types for every application • Sleeve-type, ball-type, ball-with-strap, center-pull loop fittings, "*Quickies*" for instant connect and disconnect—all of these fittings were originated by American Chain & Cable Company, Inc. Special fittings can be designed as required.

"NO-MAG" CABLES GIVE BETTER CORROSION-RESISTANCE THAN STAINLESS STEEL "No-Mag" cable is non-magnetic, won't interfere with instrument operation. In corrosion-resistance and thermal characteristics, it is superior to standard stainless steel. "No-Mag" aircraft cables also offer high fatigue and abrasion resistance, are available in a complete range of sizes in all the standard aircraft constructions.

GET THE COMPLETE STORY *on ACCO products for the aircraft industry*
Write to the Detroit Office

ACCO TRADE MARK

TRU-LOC FITTINGS

Automotive and Aircraft Division
American Chain & Cable Company, Inc.

601-T Stephenson Bldg., Detroit 2
6800-T East Acco St., Los Angeles 22 • 929-T Connecticut Ave., Bridgeport 2, Conn.

No. 186 on Reader Service Card

Minuteman Transporter-Erector. Prime Contractor—Boeing Airplane Company, Seattle Wash. Missile Container—Military Div. of Cessna Aircraft Co., Wichita, Kansas. Tractor & Trailer—GMC Truck & Coach Div., Pontiac, Mich.

MAGNESIUM LIGHTENS MINUTEMAN CARRIER...

helps keep it rigid

This huge transporter-erector will carry a Minuteman missile to its launching site, then raise it vertically, ready for placement in the underground launching silo. Magnesium was selected for many critical parts because of its stiffness and light weight . . . about 2250 pounds of sheet, plate and extrusions. This is 400 pounds *less* than the weight of the material originally considered.

The container must be light to meet highway load limits and rigid to protect the missile. For these reasons, all side panels, rear doors and access doors are made from magnesium AZ31B alloy sheet.

In the tractor unit, magnesium sheet and extrusions form the framework, panels, roof and floor. *Even the bumper* is of strong, lightweight magnesium alloy. Wherever a combination of light weight and stiffness is needed . . . for vehicle bodies, containers, housings, aircraft and missile structures . . . there's a Dow magnesium alloy to do the job. For information, write THE DOW METAL PRODUCTS COMPANY, Midland, Michigan, Merchandising Dept. 1113EW8.

DOW **THE DOW METAL PRODUCTS COMPANY**

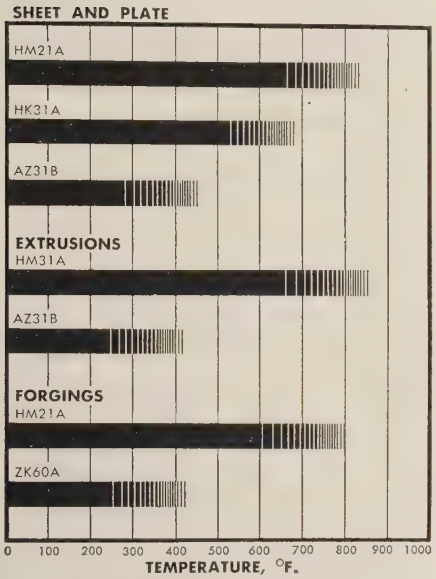
Division of The Dow Chemical Company

No. 187 on Reader Service Card

DOW

Magnesium alloys for missiles and aircraft...

HIGH STRENGTH UP TO 800°F.!



How thorium has extended magnesium's useful service temperature range.

High service temperature range and light weight . . . designers of missiles and aircraft can count on both with Dow magnesium-thorium alloys for elevated temperature use. This family of alloys offers strength and resistance to creep at high temperatures. Magnesium-thorium alloys are used in the Polaris, Titan, Talos and Bomarc missiles; in Agena and Scout vehicles; and in the F-105 aircraft.

Forgings of Dow alloy HM21A have excellent mechanical properties up to 800°F. Other alloys for extrusions, and sheet and plate, are available for use in the 300°— 800°F. range, for body skins, ducts, cowlings, electronic equipment housings, wings, fins and other applications.

Dow elevated temperature magnesium-thorium alloys are easily welded, without requiring stress relief. For detailed information and data, write THE DOW METAL PRODUCTS COMPANY, Midland, Michigan, Merchandising Dept. 1155EW8.

DOW

THE DOW METAL PRODUCTS COMPANY

Division of The Dow Chemical Company

PRESSURE TRANSDUCER gives ¼ V output

A silicon semiconductor strain gage pressure transducer that gives a 250 mv output without an amplifier with 10 V DC to 30 DC excitation is available from **Fairchild Controls Corp., Dept. S/A, 225 Park Ave., Hicksville, N. Y.**, a Fairchild Camera and Instrument Corp. subsidiary.

The transducer is available in airborne and ruggedized models. It is said to possess excellent accuracy and environmental capabilities, and to produce a high-level DC output signal that eliminates the need for impedance-matching or an amplifier. It is responsive to both static and high frequency dynamic pressures, the manufacturer reports, and is fully compatible with existing military ground, telemetry and industrial systems and interchangeable with devices now in use. Its pressure range is 0-100, through 0-10,000 psi gage or absolute, with allowable overpressure of 1.5 times rated full-scale pressure, giving a zero shift of less than +0.25 per cent.

No. 323 on Reader Service Card

VIBRATION EXCITER for field testing

This portable self-contained vibration exciter is for field calibration of vibration pickups. The compact eight-lb device operates directly from a 60-cps power line and is equipped with an amplitude indicator, says **Gulton Industries, Inc., Dept. S/A, 212 Durham Ave., Metuchen, N.J.** Designed for quick checking of small vibration pickups, the unit permits on-the-spot checking of vibration and pressure transducers without the use of elaborate and complex test equipment.

It operates on 110 V, 60 cps, five watts, is accurate within five per cent at 60 cps. The case is wood and the dimensions are 9½x8½x7 in.

No. 324 on Reader Service Card

THERMOCOUPLE GAGE is explosion proof

An explosion-proof vacuum thermocouple gage, designed for use in liquid oxygen and liquid hydrogen atmospheres, has been announced by **Fredericks Co., Dept. S/A, Bethayres, Pa.** The gage consists of a Televac meter enclosed in a heliarc-welded aluminum case, hermetically sealed, with a sealed, threaded connection to the thermocouple gage tube located outside the case.

The gage, according to the manufacturer, is also suitable for use in the explosive atmospheres generated in certain types of vacuum metallurgy, and has a range of from 1 to 1000 microns (.001—10 mm) Hg. Its single scale provides direct reading in microns of Hg pressure.

No. 325 on Reader Service Card

WAVE ANALYZER uses low-pass filters

A highly selective wave analyzer, designed for spectral analysis of random or periodic vibration signals, has been announced by **Gulton Industries, Inc., Dept. S/A, 212 Durham ave., Metuchen, N.J.** It features frequency response from 25,000 cps to as low as 0.2 cps, says Gulton.

The analyzer uses ultra-sharp cutoff low-pass filters having zero center frequency. Filter output can be fed to either a linear or square-law detector. Output RC smoothing networks have time constants that can be varied for comparison with data sweep rate and for analyzing filter bandwidth.

No. 326 on Reader Service Card

HUMIDITY CHAMBER is automatically controlled

A 6-cu-ft, portable, self-contained, automatically controlled humidity chanber has been introduced by **Wyme Laboratories, Dept. S/A, 133 Center St., El Segundo, Calif.**

Designated Model H-104, it provides a relative humidity of 95± 5 per cent at a dry bulb temperature of 160 deg F. A variable setting thermostat permits selection of other dry bulb temperatures. The chamber's interior is constructed of heliarc welded, corrosion resistant stainless steel sheet, and fiberglass insulation is used. A "fail-safe" temperature control system is incorporated, the manufacturer reports, and a programer permits humidity time cycles in conformance with Mil-E-5272C. The Model H-104 operates on a standard 110 V, 60 cycle, single phase current.

No. 327 on Reader Service Card

AIRCRAFT QUALITY

GEARS

The precision meshing of gear teeth in aircraft is the expected—but the precise meshing of Fenn facilities and personnel to meet rigid or unusual gear requirements is welcomed . . . and often unexpected. Fenn not only offers you ultra-modern gear tooth facilities (spiral bevel, too) and highly skilled personnel —but a willingness to tackle the tough ones shoulder to shoulder from engineering to final inspection. The Fenn Manufacturing Co., Newington, Conn.

Perhaps you would like to take a look at Fenn through our Facilities Folder. Write today for copy!

FENN

Precision Gears That Fly

No. 188 on Reader Service Card

TRANSDUCERS offered in wide size range

Wafer type, resistance force transducers are offered by **Clark Electronic Laboratories, Dept. S/A, Box 165, Palm Springs, Calif.**

The solid state, miniature "Micro-Ducers" are available in several dozen sizes and types, and change resistance from 500 to 26,000 ohms according to force ratings. No amplification is required, the manufacturer reports; the tranducers operate instruments, lamps, miniature motors, etc., directly within their watt rating. Wafer types without attached leads can be used in multiple, between metal plates in three or four point suspension for use in high speed weighing, as the speed of response is in the low micro-second area. The only power supply required is a flashlight cell, or 1.6 V DC regulated. Current used is less than 5 milliamps for the largest sizes, and a few microamps in others. The units are dust and moisture protected, and their operational and shelf life is said to be apparently unlimited.

No. 328 on Reader Service Card

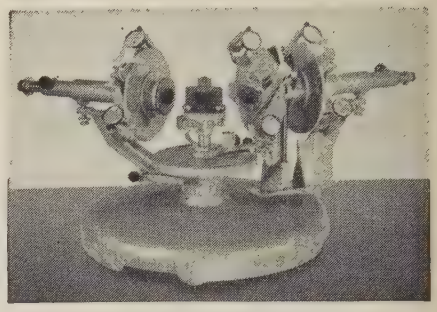
PORTABLE HEATER for space, personnel

This multi-fuel-burning portable space and personnel heater was designed for small and medium size military shelters, self-propelled vehicles and other applications. It has a 15,000 btu/hr heat output rating and is designed for cold start down to −65 deg F, says **Hunter Mfg. Co., Dept. S/A. 30521 Aurora Rd., Cleveland 39, Ohio.** The unit is 1 ft x 1 ft x 13 in. and weighs les than 40 lb.

It is an uncontaminated forced hot air type heater with an air delivery capacity of 125 cfm at sea level conditions, against back pressure of 0.2 in. H_2O. The UH-48 burns any grade gasoline and consumption is about 0.2 gal per hr when constant combustion is maintained.

No. 329 on Reader Service Card

Gaertner Ellipsometer uses polarized light to study ultra-thin films



L119 Ellipsometer with L118TN Tronstad and Nakamura Biplate Assembly

This Ellipsometer, or polarizing spectrometer, is one of many fine optical and measuring instruments designed and manufactured by Gaertner Scientific Corporation. The instrument is a basic research tool for investigating and measuring ultra-thin films, and is of particular interest to those working in the field of solid state physics. Using the methods of Drude, Rothen, Tronstad and others, it permits precise determination of film thickness from a few angstroms to 200 angstroms, or approximately to one-tenth of a microinch. It is also adaptable to the study of birefringence, index of refraction, and other characteristics and phenomena associated with thin films and surfaces.

Gaertner Ellipsometers are, in effect, dual-purpose tools. They can be readily converted to a spectrometer by adding an entrance slit to the collimator, and Gauss eyepiece and adapter to the telescope.

Gaertner offers a wide range of precision optical and measuring instruments to scientists in all fields. Our services include modifications of these instruments to meet unusual needs, complete design and manufacture of special instruments and optical systems, and manufacture of assemblies and instruments from customer sketches and drawings. ***Write for information on optical or measuring instruments used in your field. Bulletin 203-58 describes Gaertner Ellipsometers.***

Designed and manufactured in the U.S.A. by

Gaertner
SCIENTIFIC CORPORATION

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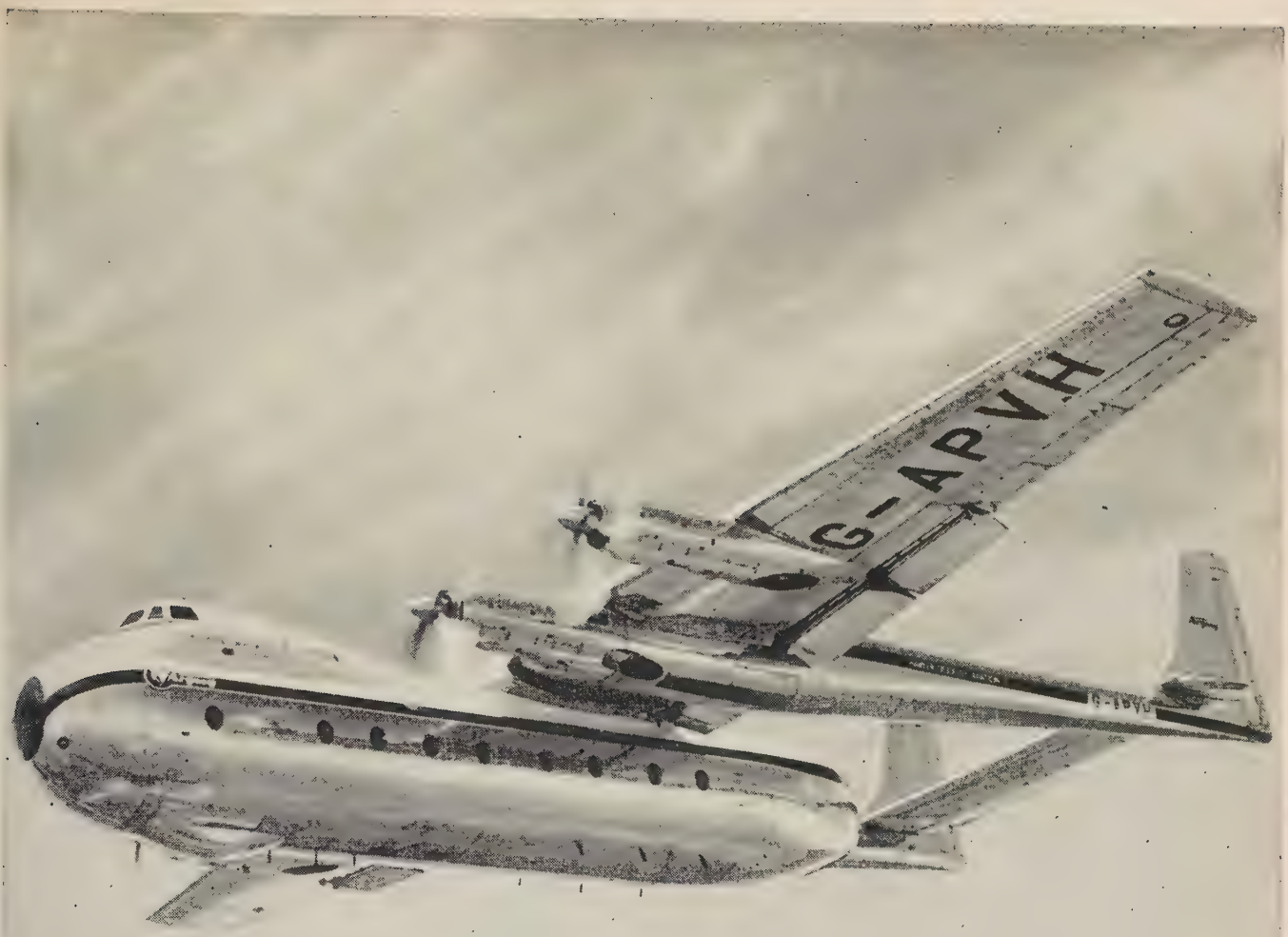
No. 189 on Reader Service Card



TODAY'S
ECONOMICAL
AIR FREIGHTER

ARGOSY

HAWKER SIDDELEY AVIATION 32 Duke Street, St. James's, London, S.W.1.

No. 190 on Reader Service Card

STRAIN GAGES have improved characteristics

A new line of solid state strain gages has been announced by **Kulite-Bytrex Corp., Dept. S/A, 50 Hunt St., Newton 58, Mass.** The new DB Series line, which replaces the company's DA and DAN gages, is said to provide higher working strain levels, increased flexibility, better handling characteristics, and smaller sizes.

The manufacturer report that the DB Series includes matched gages for a variety of materials, gages for dynamic measurements that provide 50 times greater output and one-third the "apparent strain" of conventional high-output wire gages, small gages for limited space requirements (0.1 in. gage length), and gage factors from —140 to +170. The gages are incorporated in a highly flexible epoxy matrix, and are available in resistance ranges of 120 to 5000 ohms.

No. 330 on Reader Service Card

THRUSTMETER for jet, rocket engines

Development of a simplified thrustmeter for jet and rocket engines has been announced by **Schaevitz Engineering, Dept. S/A, Rt. 130 and Schaevitz Blvd., Pennsauken, N. J.** The unit is said to be accurate within one per cent of full scale, and easy to install.

It is described as suitable for determining power available on takeoff, for matching unit outputs in multi-engine aircraft, and for general operation purposes where indication of powerplant output is required. The Thrustmeter contains three essential parts, a computer, a panel-mounted indicator in two-inch case, and a pressure rake installed at the engine's exhaust nozzle. Total weight without external cables or pressure lines is under 12 lb; power consumption is 30W, 400 cps, 155 V.

No. 331 on Reader Service Card

FLUID FILTER weighs only two oz

A 2-oz fluid filter system for general use with liquids or gases has been announced by **Pyrodyne, Inc., Dept. S/A, 11973 San Vicente Blvd., Los Angeles 49, Calif.**

The Model P/N 1850 filter features in-line ports and an adjustable by-pass. The manufacturer reports that the port arrangement allows straight-through flow, minimizing pressure drop, while the by-pass ball valve permits full fluid flow in case of filter clogging; it can be adjusted to open through a pressure drop range of 20 to 100 psig. The unit filters to 10 microns. The filtering element is a stainless steel mesh, 1⅛ sq in. in area, that can be removed from either end of the body.

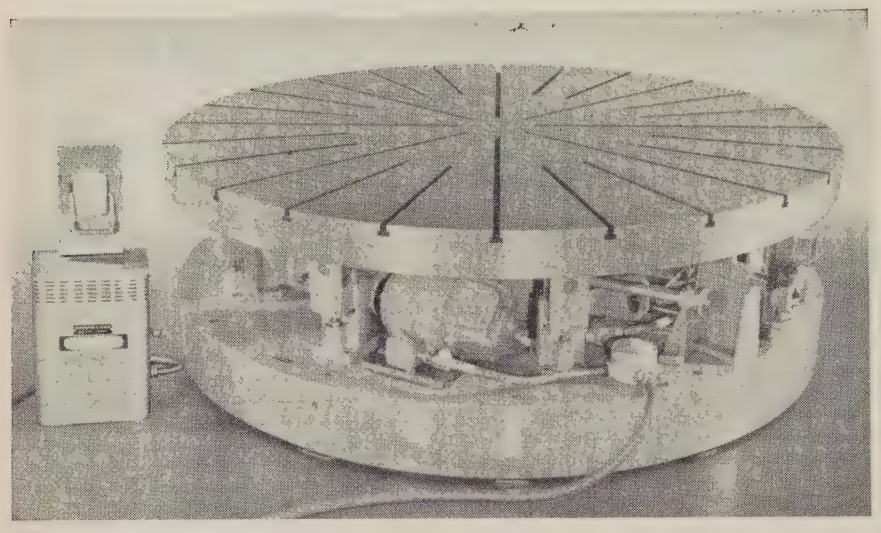
No. 332 on Reader Service Card

RECORDER for pressure, temperature

This combination pressure and temperature recorder is self-contained and uses a constant voltage sources instead of the conventional cell for standardization. It will record one or more points of pressure and up to twenty-three points of temperature, says **Wheelco Instruments, Barber-Colman Co., Dept. S/A, Rockford, Ill.** The standard unit has a temperature range of 0-800 deg. F. and a pressure range of 0-10,000 psig.

The unit was designed for use in connection with extruders in the plastic industry, but its flexibility is said to make it desirable for other industrial purposes.

No. 333 on Reader Service Card

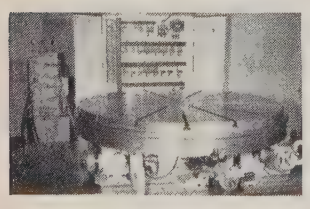


Diameter: 102″. . . Load Capacity: 90,000 lbs.

Accuracy: ±5 Seconds of Arc!

Yes, Machine Products has done it again! It's one of the largest *precision* horizontal tables ever built. Yet, in spite of its size, positioning within 5 seconds of arc . . . certified by auto-collimator . . . is easily attainable! Preliminary rotation positioning, 000°—359°, is achieved by visible counter. Final minute and second adjustments are made microscopically on a precision-graduated ring.

This table, an explosion-proof model, also features . . . variable speed motor drive from 0 to 1/3 RPM (108″ per min.) . . . high capacity cone worm gearing with positive backlash controls . . . fail-safe, self-locking braking. Interested in other sizes? They're available . . . write for complete details today.



AUTOMATIC PROGRAMMED POSITIONING

Precision index table (accuracy ±5 sec. of arc) features control band programming for automatic positioning. Interchangeable bands can carry 11 index combinations. Program your own bands or we will supply. Send for literature.

MP MACHINE PRODUCTS CORPORATION

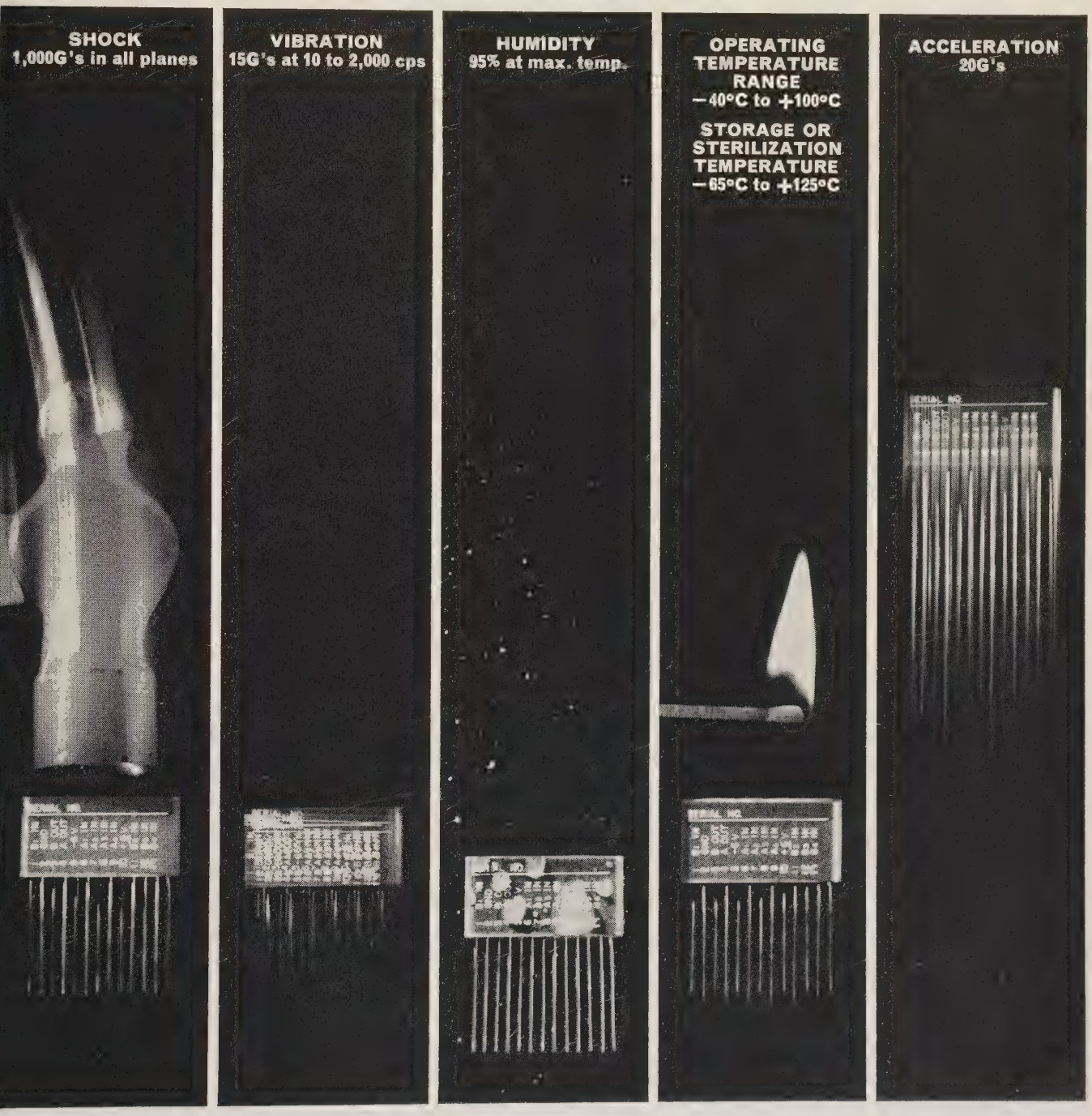
6771 E. McNICHOLS ROAD • DETROIT 12, MICHIGAN

No. 191 on Reader Service Card

LOW POWER SILICON DIGITAL MODULES

ENVIRONMENTALLY PROVED . . . AVAILABLE NOW!

Delco Radio's new silicon digital modules operate on less than 4 mw. of power per logic stage. They are rugged enough to withstand extreme environmental conditions and are small and lightweight. Encapsulated in light foamy epoxy, each module weighs less than 12 grams and occupies less than one-half cubic inch. The basic set of modules includes a bistable multivibrator, a diode NOR gate, a power driver, a monostable multivibrator and an astable multivibrator. From these basic units larger computer subassemblies can be assembled, such as shift registers, adders, binary counters, decimal counters and timing devices. A range of applications—from small scale switching circuits to large computers can be satisfied with these modules. Environmentally proved to:



Data sheets are available. Just write or call our Military Sales Department.

Physicists and electronics engineers: Join Delco Radio's search for new and better products through Solid State Physics.

PIONEERING ELECTRONIC PRODUCTS THROUGH SOLID STATE PHYSICS

DELCO RADIO

Division of General Motors • Kokomo, Indiana

No. 192 on Reader Service Card

NEW...
BLH-BUILT STRAIN INSTRUMENTS ARE EASIER TO READ, SIMPLER TO OPERATE

BLH announces new instrumentation policy. New instruments marketed by the world leader in strain and force measurement will now be designed and built entirely by instrument specialists in the modern BLH facility in Waltham, Mass. This policy will provide improved instruments with single-source responsibility and more favorable pricing.

Digital strain indicator sets a new standard for ease of operation and readout. It features digital readout to eliminate interpolation from dials and meters, wider gage factor (1.50–4.50) and gage resistance range (60–2000 ohms), battery or ac operation, and accuracy within 0.1% of reading or 5 microinches/inch. This portable unit is transistorized, weighs only 18 lb., has a durable Formica case, and is low in cost.

Switching and balancing unit, for use with any BLH strain indicator, permits readings to be taken on each of a group of gages. Speeds up test work where time is an important factor because of ambient temperature variations, creep, inherent characteristics of the test material, or limited availability of test facilities. Units can be stacked to handle gages or gage configurations in multiples of 10. Simplified gage connection board. Special friction drive zero adjustments require no locking.

Improved repeatability—better than 1 microinch/inch for a half-million channel selector switch rotations. Long-life Formica case.

Local availability through BLH sales engineering representatives in the U.S. and Canada. See the one nearest you or write direct for data sheets.

BALDWIN • LIMA • HAMILTON
Electronics & Instrumentation Division
Waltham 54, Mass.

FIRST in force measurement

SR-4® Strain Gages • Transducers • Temperature Sensors • Systems

PRESSURE TRANSDUCER for aerospace applications

A miniature pressure transducer is described by its manufacturer, **Taber Instrument Corp., Dept. S/A, N. Tonawanda, N. Y.,** as capable of withstanding the severe accelerations and vibrations of missile and rocket flights.

Designed for airborne applications involving the precise electrical measurement of fluid and gas pressures from 0 to 50 psia or psig, the "Teleflight" Model 179 maintains a pressure measurement accuracy of 0.25 per cent over a wide temperature range, according to the manufacturer. Its high quality stainless steel housing is said to permit measurement of most fluids and gases, including corrosive substances. Its four precision strain gages are bonded to a one-piece, Ni-Span-C proving ring, which acts as a heat sink under zero-G conditions.

Also available is the "Teleflight" Model 183, which measures fluid and gas pressures up to 200 psia or psig.

No. 334 on Reader Service Card

STORAGE VESSELS for high pressure use

A new product line — high pressure gaseous storage vessels — has been developed by the **Garrett Corp., AiResearch Manufacturing Div., 9851 Sepulveda Blvd., Los Angeles, Calif.**

The storage vessels are designed for operating pressures up to 20,000 psi. They are said to be suitable for any high pressure gaseous application, airborne or ground. The vessels are made of 4340 steel, and have successfully undergone 100-g shock tests, the manufacturer reports.

No. 335 on Reader Service Card

SIMULATOR for aircraft wiring checkout

A trailer-mounted simulator has been developed by **Hamilton Standard Div., United Aircraft Corp., Dept. S/A, Windsor Locks, Conn.,** for checkout of the wiring of 54H60 turbine hydromatic propellors.

The manufacturer reports that the unit can make 100 checks of electrical circuits in ½ hr, operated by untrained or semi-trained personnel. It trouble-shoots each circuit of the aircraft's electrical propellor system for continuity, insulation leakage, shorts, grounds, line resistances, and voltages. Fully enclosed and waterproof, the unit consists of switch assembly, volt-megohmmeter, battery and cables, and has facilities for substituting ground power for the battery if necessary. It measures 3 x 4 x 6 ft, and weighs 500 lbs.

No. 336 on Reader Service Card

No. 138 on Reader Service Card

TRANSPONDER TESTER for ground checkout

This go-no-go transponder function tester was developed for use in ground checkout of installed transponders, such as the AN/APX-44. The unit, model 860A, produces a signal when triggered from within a foot or two of the antenna. This signal activates the aircraft transponder and a lamp on tester indicates whether the transponder has emitted a responding signal.

According to **Wilcox Electric Co., Inc., Dept. S/A, 14th and Chestnut Sts., Kansas City 27, Mo.,** the package design and transistorized circuitry resulted in a test set which permits high speed checks on an individual or fleet basis with minimum operator-training time and maintenance. The tester weight is less than four lbs, and it operates from four self-contained standard 1½ volt batteries.

No. 337 on Reader Service Card

LOAD CELL offers good lateral stability

A new load cell, designated Type BL-1, has been added by **United Aero Products Corp., Dept. S/A, Burlington, N. J.,** to its line of force transducers.

The BL-1 has a precisely-machined stainless steel bellows coupled inductively to an ultra-sensitive differential transformer, the manufacturer reports. It is said to have a low profile (less than ¼ in.) that insures excellent lateral stability, and to provide high continuous output with exceptional accuracy and repeatability. It uses no solder, plastic, or other bonding agents. The load cell's diameter is 1¾ in. Hysteresis error is less than 0.1 per cent and temperature range is from −85 to 500 deg F. The BL-1 is available in ranges from 5 to 500 lbs.

No. 338 on Reader Service Card

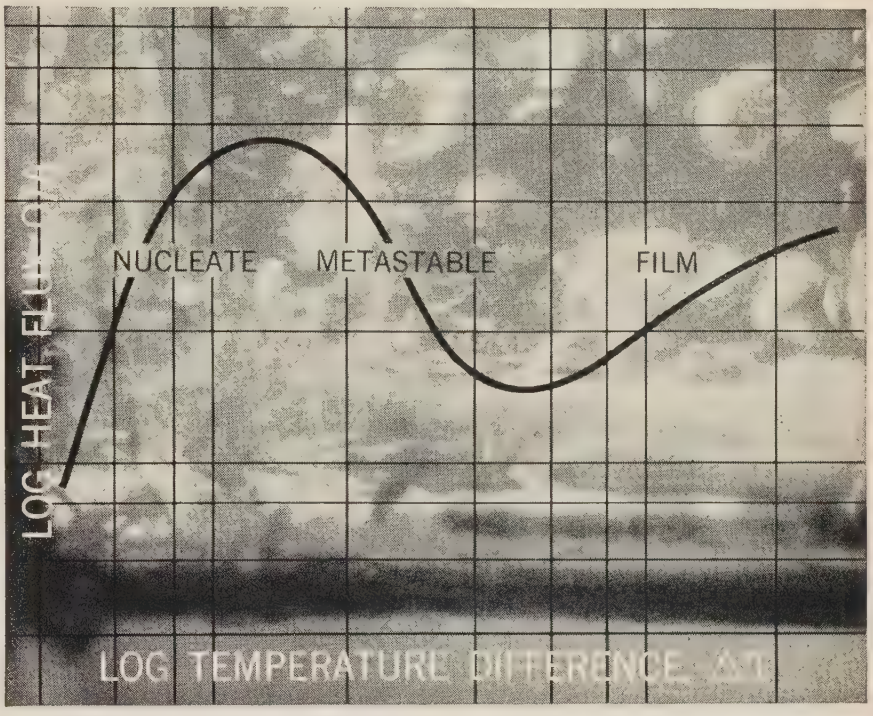
ENVIRONMENTAL CHAMBER reaches new low temperature

An environmental chamber with a mechanically refrigerated closed system is announced by its manufacturer, **Webber Manufacturing Co., Dept. S/A, P.O. Box 217, Indianapolis 6, Ind.,** as the first such chamber able to reach −250 deg F.

The manufacturer suggests that the Model WT-8-250 may be used for space vehicle component testing, for increasing the life of processing dies, tools, drolls and broaches, blood storage, instrument calibration, gas dehydration, liquifaction of gases, metal hardening, and nuclear radiation testing.

No. 339 on Reader Service Card

TECHNICAL ADVANCES FROM BENDIX PIONEER-CENTRAL **CRYOGENICS**



This remarkable photo of liquid nitrogen (−320.4°F.) shows all three boiling modes—nucleate, metastable, and film boiling—on a single surface at a single heat flux.

CRYOGENIC KNOW-HOW THAT CAN PAY OFF FOR YOU!

The curve above was experimentally determined at Pioneer-Central to describe boiling heat transfer in a cryogenic fluid. It typifies our comprehensive background in the general field of heat transfer—from solid surfaces to boiling liquids.

We apply this knowledge daily to the development of important cryogenic devices, such as optical liquid sensors, LOX converters, pressure suit ventilating systems, fuel utilization and mixture ratio controls, and propellant loading controls. Find out how these facilities and capabilities can help solve *your* cryogenic problems.

Other areas of outstanding Pioneer-Central capabilities include—Inertia and Pressure Sensing Instrumentation, Life Support, Fuel Management, and Sonic Energy Cleaning.

ENGINEERS are invited to investigate the diversified opportunities at Pioneer-Central. All qualified applicants will receive consideration for employment without regard to race, creed, color, or national origin.

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No. 196 on Reader Service Card

AUTOCLAVE ENGINEERS ERIE, PA.

AIR-OPERATED VALVES

Pressures to 5,000 p.s.i.

Your need for air-operated valves in systems with limited space is answered here. Light weight . . . easy to install, these new AE Air Operated Valves are far more compact than any such units thus far offered. They're designed for on-off use with 1/8, 1/4, 3/8 or 9/16 inch stainless steel tubing and for pressures up to 5,000 p. s. i. Your choice of either air-to-open or air-to-close designs.

Complete information is offered in Bulletin 361—yours for the asking.

AUTOCLAVE ENGINEERS, INC.

2933 West 22nd Street • Erie, Pa.

Designers and Builders of High Pressure-High Temperature Equipment including: Valves • Fittings • Stirred Autoclaves • Reactors • Pumps • Compressors • Complete High Pressure Package Systems including Instrumentation and Controls.

THERMOCOUPLE WIRE uses noble metals

A noble metal thermocouple combination has been developed by **Engelhard Industries, Inc., Dept. S/A, 113 Astor St., Newark 2, N. J.,** for temperature measurement. Designated Platinel, it uses gold, palladium, and platinum to supply an electromagnetic force output equal to that of the company's Chromel-Alumel, and a high degree of stability over an extended temperature range.

Initial tests indicate a drift of only 2 deg in emf output after a 2500-hr test at 1300 deg C, the manufacturer reports. Use of noble metals is also said to make lighter wire gage sizes practical, with the consequent reduction in mass for faster response. Platinel is available in wire form and as part of complete thermocouple assemblies.

No. 452 on Reader Service Card

AC/DC CONVERTER for missile checkout

Automatic selection of AC voltage range is now possible for guided missile checkout by means of the Model 125E AC/DC converter. Developed by **Non-Linear Systems, Inc., Dept. S/A, Del Mar, Calif.,** the unit can be used with a digital voltmeter to select proper range and display readings of four digits.

Input voltage range is one mv to 1000 V; input impedance is 10 megohms. Response time is reported to be very short—output voltage is within 0.01 per cent of final value in less than six sec, even at 30-cps frequencies. Typical uses of the 125E include guided missile checkout, testing inertial guidance devices, and checkout of telemetry systems.

No. 453 on Reader Service Card

PRESSURE TRANSDUCERS for high temperatures

Two pressure transducers, Models 538B and 539B, featuring precycled, prestabilized, standardized operation in temperature environments ranging from —100 to +600 deg F are available from **Electro-Mechanical Research, Inc., Dept. S/A, Box 3041, Sarasota, Fla.** They are designed to operate in these temperatures during shocks in excess of 100g for 11 msec in any direction.

Performance is said to be standardized to such close tolerances tha models covering identical full-scale ranges may be interchanged without recalibrating the measuring system. Both models are miniature units of the bonded strain-gage type.

No. 454 on Reader Service Card

No. 197 on Reader Service Card

They make piston pins faster for less money with USS National Seamless Mechanical Tubing

It takes plenty of machine time to drill and machine the holes in 6,500,000 piston pins a year. That's what one major auto company* had to do . . . *until* the switch to USS National Seamless Steel Mechanical Tubing. By eliminating the need to drill holes in the bar stock, the company got rid of six chuckers formerly used for drilling, saved time as well as the power they consumed and the space they occupied. ☐ USS National Seamless Tubing has dimensional accuracy. It has no hard or soft spots. It's made by people who know more about seamless tubing than any other manufacturer in the world. You can choose from a complete range of sizes and steel grades. Find out how USS National Seamless Mechanical Tubing can be most effectively applied to your designs. Contact your nearest National Tube Distributor soon.

USS and National are registered trademarks

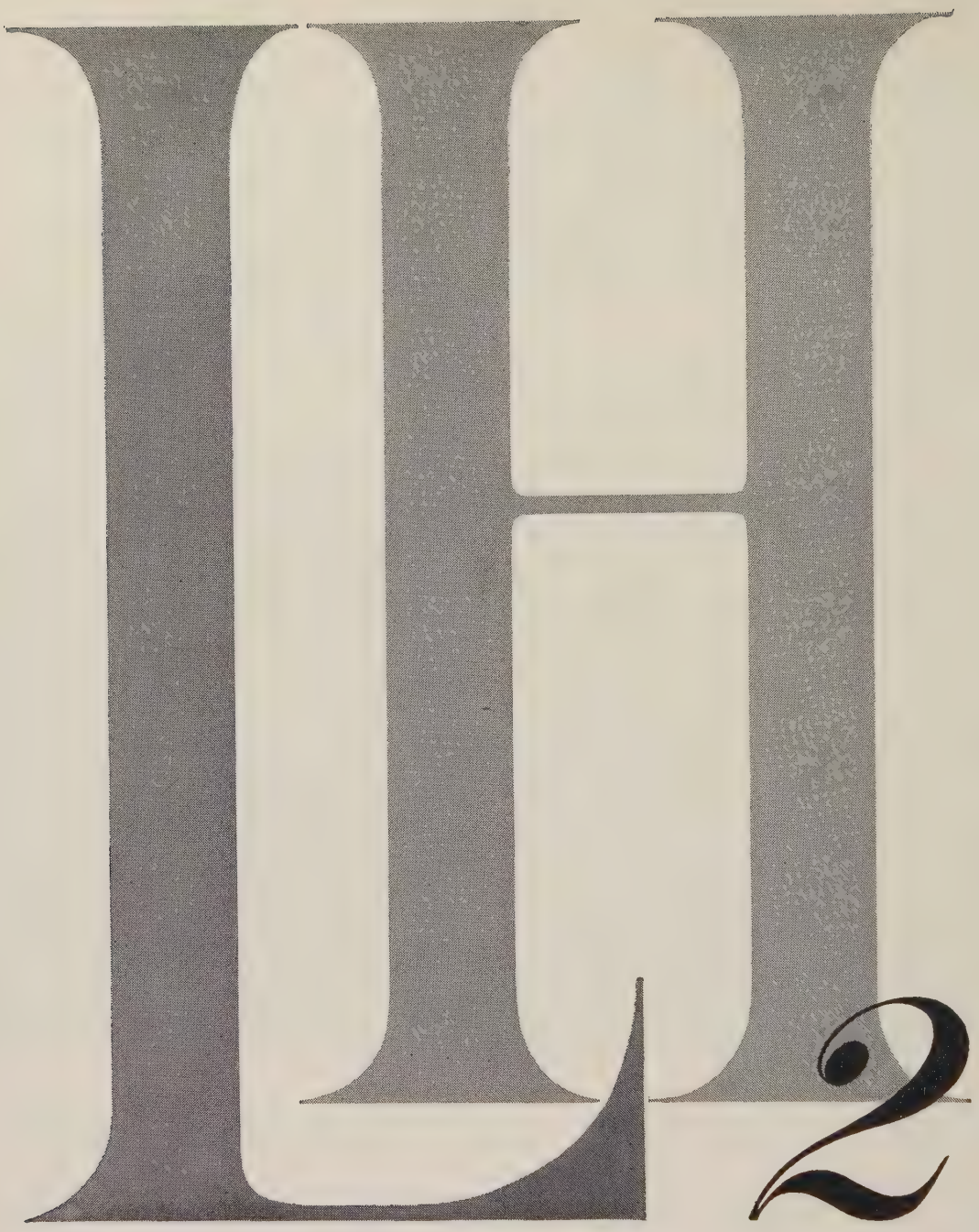
**Name supplied on request*

National Tube Division of United States Steel

Columbia-Geneva Steel Division, San Francisco, Pacific Coast Distributors
United States Steel Supply Division
United States Steel Export Company, New York

This mark tells you a product is made of modern, dependable steel.

No. 198 on Reader Service Card



Air Products pioneered in the application as well as the production of liquid hydrogen . . . the ultimate fuel . . . for missiles and rockets. Examples: the test facilities for KIWI, and test facilities for even newer missiles. Air Products possesses missile propellant system capabilities few others can match. If you have a problem in propellant systems, look to Air Products first for the answer.

Air Products
...INCORPORATED
A NEW DIMENSION IN INDUSTRY

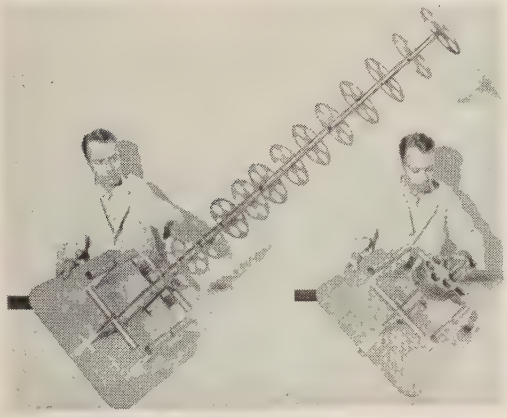
DEFENSE & SPACE DIVISION: General Office: Allentown, Pa. DISTRICT LOCATIONS: Dayton, Ohio; Washington, D. C.; Los Angeles, Calif.; Winter Park, Florida.

No. 199 on Reader Service Card

ELECTRONIC equipment preview

For details of equipment in this section, write in item number on Reader-Service Card

COLLAPSIBLE ANTENNAS FOR QUICK ERECTION FUNCTIONS



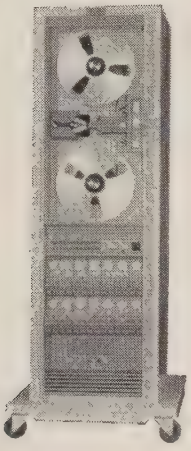
The first unit, Model #521A, in a new line of modular collapsible antennas, designed for a variety of "quick erection" functions in the 350- 600-mc frequency range, has been announced by Avien, Inc., 58-15 Northern Blvd., Woodside 77, New York. In addition to the quick feature, the 521A can also be collapsed within minutes for transportation to a new site.

The new antenna is a four-element array measuring 31x6x7 ft in operation and collapsing to four by four feet by 20 in. It can be broken down further for storage. The entire array weighs only 95 lb, including manual pedestal.

According to Avien, the 521A has a gain of 17 to 20 lb, is capable of operating in 100 mph winds, with ice, and has a power handling capability of over one kilowatt.

Applications of the 521A include scatter communications, point-to-point communications, frequency diversity, polarization diversity, tactical surveillance, and trading and data receiving. **61**

Multiple-Speed Instrumentation Recorder Handles up to 14 Tracks of Information



An all-new, fully transistorized instrumentation recorder-reproducer, Model G-100 has been announced by the Minicom Div., Minnesota Mining and Manufacturing Co., 2049 S. Barrington Ave., Los Angeles 25, Calif. A speed selection control gives a choice of six standard speeds from 3¾ to 60 ips. Up to 14 tracks of information plus a separate voice annotation track can be accommodated in a single compact rack.

The unit features a wide dynamic range and a built-in calibration which allows the recorder to be preadjusted to the incoming signal amplitude. At 60 ips, the G-100 has a bandpass of 200 cps to 300 kc using analog modules, and DC to 20 kc using FM modules. At lower speeds the frequency response is extended to 50 cps. All speeds are phase-equalized for maximum fidelity of reproduction.

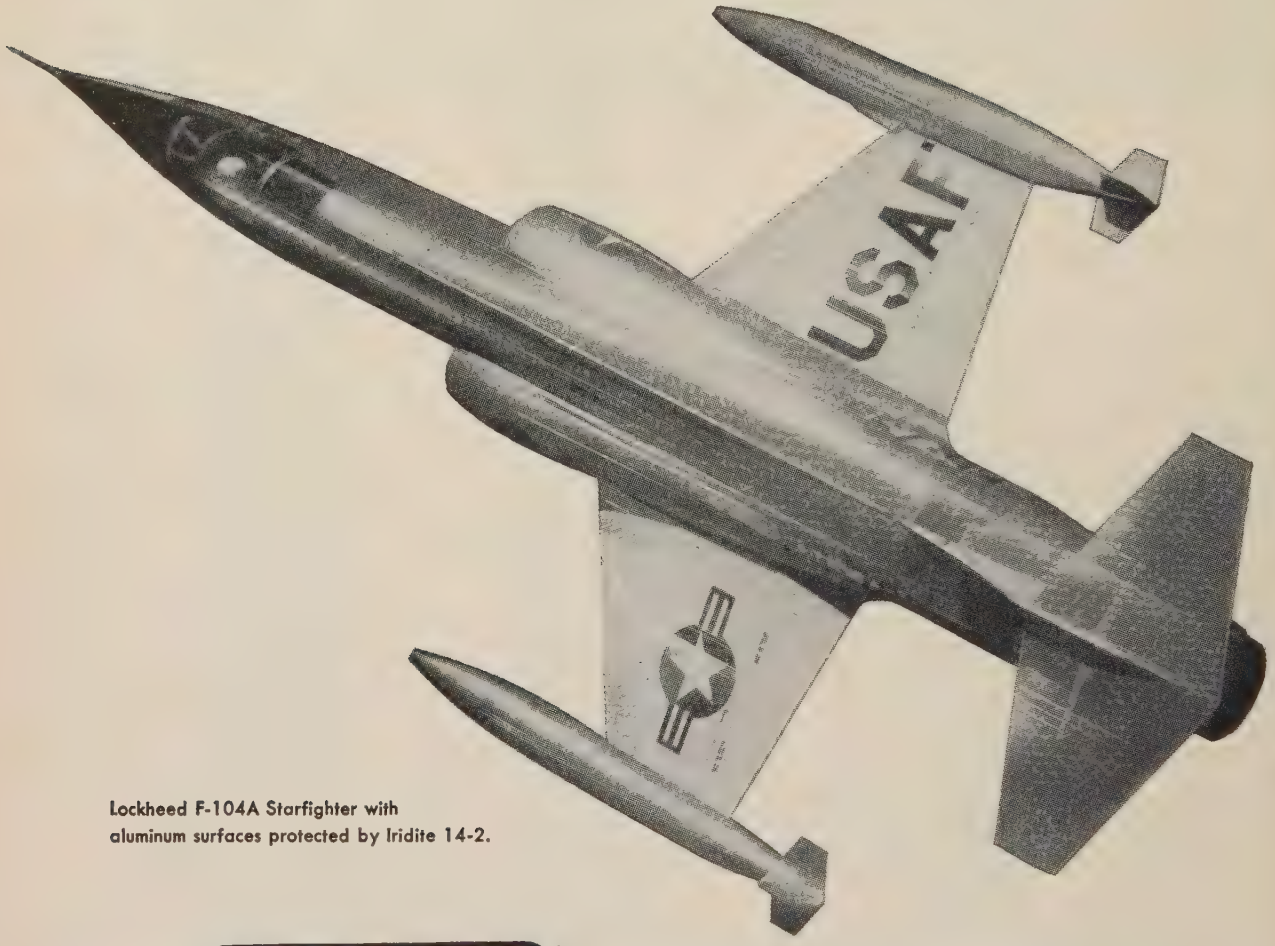
A modular design approach lets the entire record-reproduce circuitry for a given track be removed as a single unit, thereby permitting ease of maintenance and rapid replacement. Individual plug-in cards on each module contain the read-write circuits which can be changed by plugging in different cards. The module also contains the associated relays and plug-in equalizers.

The G-100 is available with either FM or analog record-reproduce modules, delivery 60 days after receipt of order. **57**

Converter for Pointer Instruments Provides Digital Output

A general-purpose digital converter that can be attached to a conventional pointer-type instrument to provide a digital output of the instrument's reading has been announced by the MacLeod Instrument Corporation, 4510 N.W. 10th Avenue, Fort Lauderdale, Fla. This converter is expected to prove extremely useful in connection with instruments for which there are no counterparts that provide direct digital outputs, as well as for the elimination of human errors met in reading dial type instruments.

Looking For Savings? Then Read . . .



Lockheed F-104A Starfighter with aluminum surfaces protected by Iridite 14-2.

How IRIDITE® Helps Lockheed Cut Aluminum Finishing Costs

Nine years ago, Lockheed switched from anodizing to Iridite chromate conversion coatings. That year, they saved over $40,000 in materials and manpower.

Today, Lockheed is still saving money with Iridite 14–2. Here's how:

Process time is reduced from 45 minutes to a maximum of only 5 minutes. Three times as much work is processed in a single run. Easy-to-load baskets, replacing costly anodizing racks, save $15,000 per year. Expensive electrical equipment is eliminated because Iridite is a simple chemical dip.

Moreover, Iridite 14–2 gives improved corrosion resistance, easily meeting MIL–C–5541, and provides excellent paint adhesion.

More than likely, Iridite can save you money and give you better finishing results than your present method. Discuss it with your Allied Field Representative. Or, write for literature.

Allied Research Products, Inc. 4004-06 EAST MONUMENT STREET • BALTIMORE 5, MARYLAND
BRANCH PLANT: 400 MIDLAND AVENUE • DETROIT 3, MICHIGAN
West Coast Licensee for Process Chemicals: L. H. Butcher Co. • European Agent: Sture Granberger, Storgatan 10, Stockholm, Sweden

Chemical and Electrochemical Processes, Anodes, Rectifiers, Equipment and Supplies for Metal Finishing

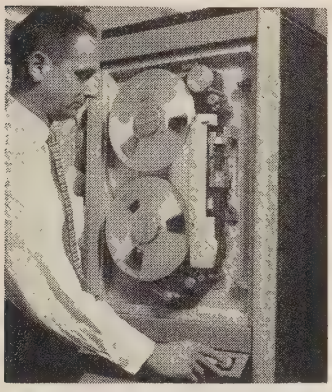
IRIDITE® Chromates | IRILAC® Coatings | ISOBRITE® Brighteners | ARP® Supplies | WAGNER Equipment

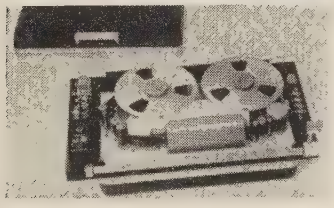
No. 200 on Reader Service Card

The converter consists of two basic units, a scanner (see *Photo*) that attaches by means of adapters to the instrument to be "read" and an electronic unit that houses the electronic circuitry and digital display. An electrical output having any of the standard codes is available for operation of a digital printer, card punch, or tape punch

In operation, the scanner senses the position of the instrument pointer and its reference or zero position and translates the relative angular displacement to a time interval. This in turn is measured by conventional digital techniques and translated to the desired binary or digital form. The scanning frequency may be as high as 10 scans per second, and the resolution is 1 part in 1,000. The scanner imposes no mechanical load on the instrument pointer. **58**

Wide-Band Recording System Has Extended Range





Its wide-band AR-300 and FR-700 recording system, says Ampex Corp., Redwood City, Calif. will make it possible to capture phenomena presently far beyond the range of other magnetic-recording equipment. The system comprises an airborne AR-300 unit (*top*) that records only, while the FR-700 ground unit (*bottom*) is a complete recording and reproducing system. Both units can record two channels of wide-band information from 10 cps to four megacycles. The amplitude response is flat to within three decibels over this range.

Completely transistorized, the system features a pair of rotating wide-band heads for dual-channel transverse recording and multiple fixed heads or lateral recording of vital timing, control, and monitor signals. The AR-300 can operate from —54 to 55 deg C, from sea-level to 50,000 ft altitude, and at up to 100 per cent relative humidity. It is fully enclosed in an airtight metal and fiberglass case with built-in shock absorbers. **88**

equipment in brief

OSCILLATOR-TRANSDUCER used for telemetry

Model TP54 variable reluctance transducer with a transistorized oscillator is now available for use in missile and aircraft telemetry systems. Manufactured by **Pace Engineering Co., Dept. S/A, 13035 Saticoy St., North Hollywood, Calif.**, they are available in both gage and absolute models. The units include a buffer amplifier and regulated power supply for operation with a 28-volt DC supply.

The oscillator-transducer will accept corrosive materials as working fluids. They are available in ranges from 0-15 to 5000 psi. Output frequency deviation is said to be ±7½ per cent about center frequency. Output voltage is 3-5 volts across a 10-K load. Linearity is reported ±5 per cent, best straight line and hysteresis within 0.5 per cent maximum pressure excursion.

No. 459 on Reader Service Card

System Development • Communications • Data Link • Countermeasures Actuators • Missile, Weapon and Space Vehicle Research • Infra-Red and Microwave R & D.

ELECTRONIC COMMUNICATIONS, INC.
St. Petersburg, Florida

RESEARCH DIVISION
Timonium (Baltimore), Maryland

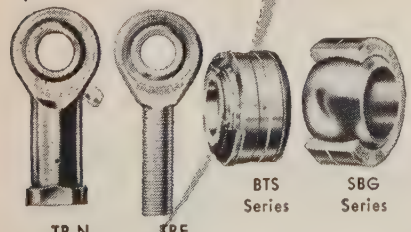
ADVANCED TECHNOLOGY CORPORATION (ADTEC)
Santa Barbara, California

No. 201 on Reader Service Card

SPHERCO
BEARINGS & ROD ENDS

AVAILABLE IN A COMPLETE RANGE OF SIZES

If you have applications involving linkage or transfer of motion, SPHERCO Bearings can supply your needs in a wide variety of materials with a quality that will give you top performance under normal or high temperature conditions.



WRITE FOR BULLETIN 560

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No. 202 on Reader Service Card

COMMAND RECEIVER for space satellites

This lightweight command receiver is for use in space satellites. It weighs 1.5 lb, measures 6.3 in. in diameter, and is 1.13 in. high, according to the **Electronics and Ordnance Div., Avco Corp., Dept. S/A, Cincinnati 15, Ohio.** Transistors and solid state components contributed to the small size and weight.

The unit's purpose is to receive radio instructions from ground stations to actuate the satellite's electronic equipment. As the receiver accepts signals, it feeds them to the decoder to activate on-off control. The decoder, which weighs 2 lb, accepts seven separate radio commands.

No. 340 on Reader Service Card

S-BAND DUPLEXER switches 7 megawatts

An S-band duplexer capable of switching seven megawatts of incident peak power has been developed by **General Electric Co., Dept. S/A, Schnectady 5, N.Y.** The duplexer uses secondary electron resonance (multipactor) for switching, rather than gas discharge. In multipactor discharge, electrons in high vacuum are driven back and forth between two electrodes by an RF electric field.

The multipactor discharge occurs in an evacuated transmission type cavity which performs the functions of a TR switch. As designed, the TR cavity is capable of switching 3.5 megawatts and providing isolation of 23 db. A dual TR cavity, in conjunction with two side-wall hybrids, constitutes a balanced duplexer capable of switching seven megawatts.

No. 341 on Reader Service Card

CRYOGENIC SYSTEM for electronic cooling

A self-contained miniature cryogenic cooling system is now commercially available, says **Air Products, Inc., Dept. S/A, Allentown, Pennsylvania.** The closed cycle system uses nitrogen to provide one watt of refrigeration at 80 deg K.

The system is designed to run continuously for 500 hours between maintenance periods, says the company. Both a 400-cycle, 208-volt, 3-phase design for airborne use and a 60-cycle, 115-volt, 1-phase design are available. The entire system weighs 16 lb. It is possible to separate the compressor and refrigerating element for remote cooling applications.

No. 342 on Reader Service Card

TELEMETRY DISCRIMINATOR is portable

An all solid-state portable telemetry sub-carrier discriminator, the Mini-Tel, is available for use when space is at a premium. The unit is a pulse averaging discriminator which provides reliable monitoring functions at test sites and other field installations, says **Precision Instrument Co., Dept. S/A, 1011 Commercial St. San Carlos, Calif.** In a single module, he discriminator accommodates 14 standard IRIG channels in front panel plug-in units, each with optional output monitoring. Power requirements are less than 3 watts per channel.

The unit is reported to be very stable, with DC drift practically nonexistent in a controlled environment, and under 1 per cent over a temperature range of 80 deg F. DC linearity is better than 0.5 per cent. With flat frequency response low-pass filters, the output level is flat within ±0.5 db.

No. 343 on Reader Service Card

MICROWAVE DIODES have high Q

High Q, high breakdown voltage diodes are available with frequencies as high as 100 kmc and capacitance values as low as 0.15 pf at −6 volts. The diodes are obtainable in a double ended ceramic package and in the Micro-Min construction. The Micro-Min units are one-tenth the size of conventional units, says **Sylvania Electric Products, Inc., Dept. S/A, 730 Third Ave., New York 17, N.Y.** These are especially suited for printed circuit usage in microwave equipments.

These silicon epitaxial varactor diodes feature exceptional power handling capability as harmonic generators. As doublers at L-band, they show conversion efficiencies as high as 70 per cent.

No. 344 on Reader Service Card

SHOCK ABSORBER for radar antenna

A miniature shock absorber, the Model 409, 8 SS Liquid Spring Shok, has been announced by **Taylor Devices, Inc., Dept. S/A, N. Tonawanda, N.Y.**

The unit, which is said to be in use on an airborne radar antenna, measures 1⅛ in. in body length and ½ in. in outside diameter. It absorbs 175 in./lb of energy in 1/10 in. stroke. The 800-lb force spring opeates in 1/10 in. stroke with 80 lb preload to .04 in. stroke with 400 lb. preload.

No. 345 on Reader Service Card

DELAY LINE for computer uses

This lumped constant delay line features a delay total of 2.4±0.2 micro-seconds, says **Essex Electronics Div., Nytronics, Inc., Dept. S/A, 550 Springfield Ave., Berkeley Heights, N. J.** The delay line has a maximum noise output of 0.2 volt.

Electrical characteristics are: maximum output rise time of 0.165 micro-seconds; 15 per cent maximum attenuation; and impedance of 300 ohms ±5 per cent. Additional characteristics include: input pulse width of 0.75 microsecond; input pulse voltage of 5.0 volts; and input pulse rise time of 0.05 microsecond. The delay line is 7⅜ in. x 1¾ in. x 0.406 in.

No. 346 on Reader Service Card

TRANSMITTER is transistorized

A transistorized crystal-controlled transmitter is now available for uses where an extremely compact, low power, rugged unit is required. This all silicon, phase-modulated unit is reported capable of transmitting intelligence from any telemetry subcarrier system, says **Vector Manufacturing Co., Inc., Dept. S/A, Southampton, Penna.**

Performance characteristics include: power output—50 milliwatt nominal; output impedance—50 ohms; frequency range—215 to 260 mc; frequency tune-up tolerance — ±0.005 per cent; modulation frequency range —100 cps to 200 kc; input impedance —5 K minimum; peak deviation—±150 kc maximum, ±125 kc nominal; modulation sensitivity—0.2 volts rms for a modulation index of 1 measured at 1 kc; power requirements—28 volts ±10 per cent at 80 milliamps.

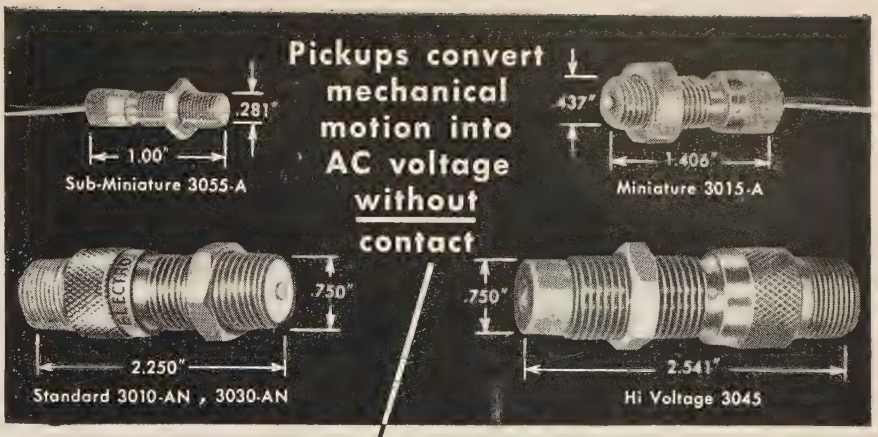
No. 347 on Reader Service Card

WIDEBAND DC AMPLIFIER has low noise level

A wideband DC amplifier designed to amplify signals from strain gages, thermocouples, and other low level signal devices is announced by **Computer Engineering Associates, Inc., Dept. S/A, 350 No. Halstead, Pasadena, Calif.** The Model AI 233 amplifier has a bandwidth of dc to 40 kc and a maximum noise level of less than 12 uv to 50 kc, says the company.

Minimum input impedance is 100,000 ohms over the full bandwidth. It has an output of ±50 V at ±50 mamp. Circuits and chassis are isolated to permit use of grounded or floating signal sources and recorders.

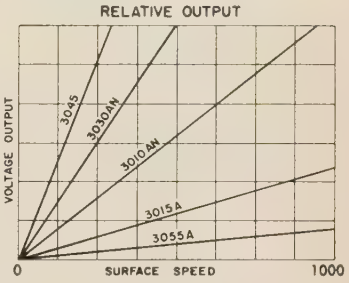
No. 348 on Reader Service Card



Solve speed/control problems

These standard magnetic pickups generate voltage and power without the aid of additional power sources. They actuate electronic or electrical circuitry without amplification in most cases. No extra bearings, mechanical linkages, etc., are required.

A wide variety of stock models are available for immediate delivery, and unlimited variations can be engineered on special order.



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1242

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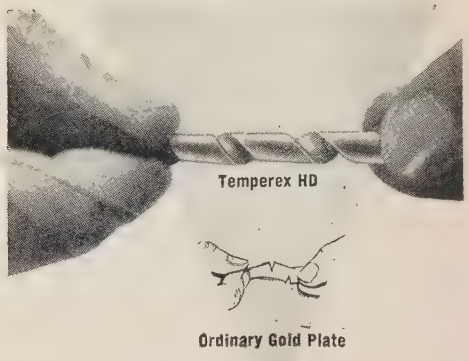
Extra High Purity Gold Plate!



Sel-Rex® TEMPEREX® HD*

TEMPEREX HD electroplate meets or surpasses the most exacting specifications of the electronics industry. Its deposits of 99.99+ purity provide a uniformity of metallurgical characteristics never before attainable in gold electroplate.

Other advantages: 75 Knoop hardness; easy to solder or weld; and an exceptional ductility that permits *cork-screw twisting of electroformed strips without fracturing!*

Write for details.

*Patent applied for

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World's largest selling precious metal plating processes

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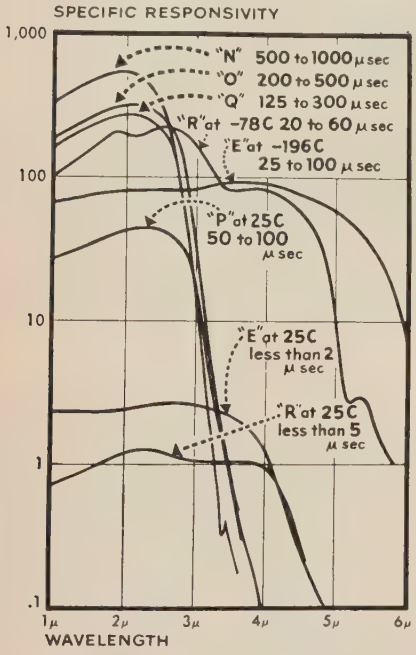
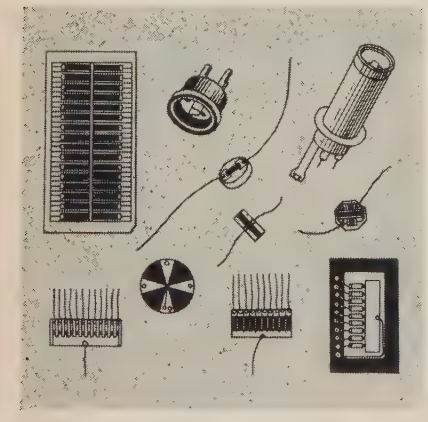
KODAK EKTRON DETECTORS

-for the 1μ to 6μ infrared



a wide-open choice in spectral responsivity and time constant



a wide-open choice of physical forms —large, small, complex shapes, multiple arrays, "immersed," Dewar-housed—ingenuity is the only limit, almost

For more precise explanations and a price list of off-the-shelf Kodak Ektron Detectors (or to see if we can build a complete infrared system for you), write—

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No. 205 on Reader Service Card

S-BAND ISOLATOR for missile uses

This ultra miniature, S-band isolator is useful in missile and satellite applications and in replacing resistive pads. The model X-173A, covering 2.6 to 3.3 kmc, has an isolation greater than 10 db with 18 db at band center, according to **Melabs, Dept. SA, 3300 Hillview Ave., Palo Alto, Calif.** All models are said to have an insertion loss of less than 1 db and a VSWR of 1.2:1.

The model X-173B, 2.7 to 2.9 kmc, has an isolation greater than 14 db. Isolation of Model X-173C, 2.95 to 3.25 kmc, is also greater than 14 db. Each isolator weighs 6 oz and is 3½ in. long.

No. 349 on Reader Service Card

VLF RECEIVER operates in 14-30 kc band

The model R-500 VLF time and frequency receiver is designed to receive signals from stations operating in the 14-30 kc band. This pre-tuned unit is available from **Instrument Corporation of Florida, Dept. S/A, Melbourne Municipal Airport, Melbourne, Fla.**

Time signals are a 1000-cycle mark of same duration as the transmitted signal. Output is 1 volt. The unit operates from 115-volt, 60-cps power, and voltage regulation is provided to correct for variations from 105 to 130 volts. It is reported that time accuracy to approximately 500 microseconds may be anticipated, with controlled accuracies to 100 microseconds. The unit is designed for installation in a standard 19-in. rack, requiring 7 inches space. Total weight is about 35 lb installed.

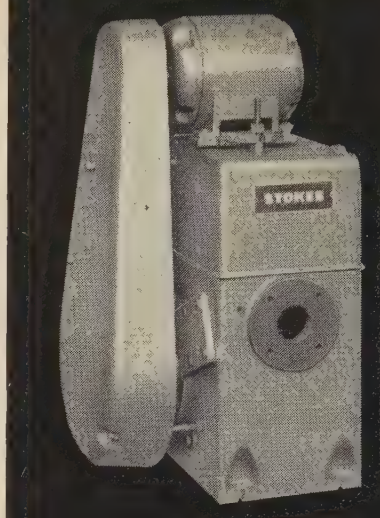
No. 350 on Reader Service Card

COMMUTATION SIMULATOR for PAM and PDM signals

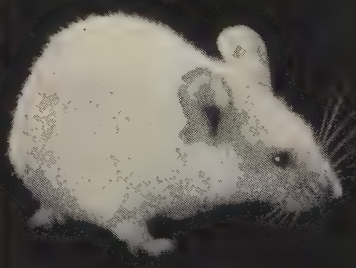
Exact simulation of PAM and PDM signals produced by telemetry systems is now possible with the ESS 305 all-electronic telemetry simulation system developed by **Telemetrics, Inc., Dept. S/A, 12927 S. Budlong Ave., Gardena, Calif.** Applications include a commutation rate range of 10 to 10,000 channels per sec, NRZ operation, and high flexibility of channel input data. Commutation rate is continually adjustable in six bands.

According to Telemetrics, information accuracy is within + 0.15 percent of full scale, output linearity is within +0.10 per cent of full scale, output stability is +0.15 per cent. Pulse rise and fall is less than 3.0 us PAM less than 0.50 us PDM.

No. 351 on Reader Service Card



a vacuum pump as quiet as a . . .



Steady and silent. That's the new Stokes Series H Microvac pump. Unique dynamic balancing provides hushed operation. And the compact Stokes pump saves up to 50% in valuable floor space.

Find out all the reasons why you get *more pumping performance per dollar* with Stokes Microvac pumps. Just write: Vacuum Equipment Division, F. J. STOKES CORPORATION, 5500 TABOR RD., PHILA. 20, PA.

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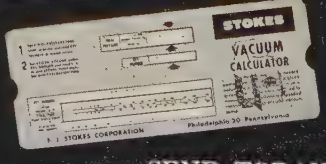

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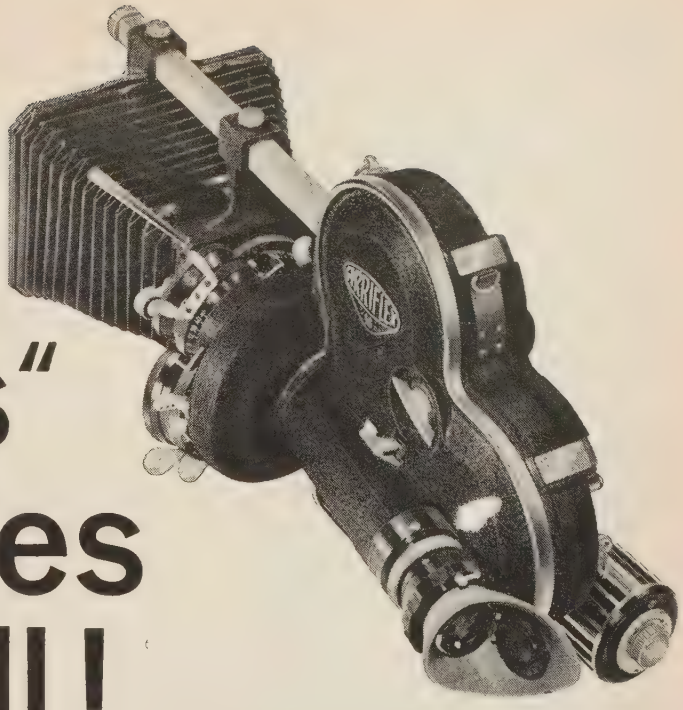
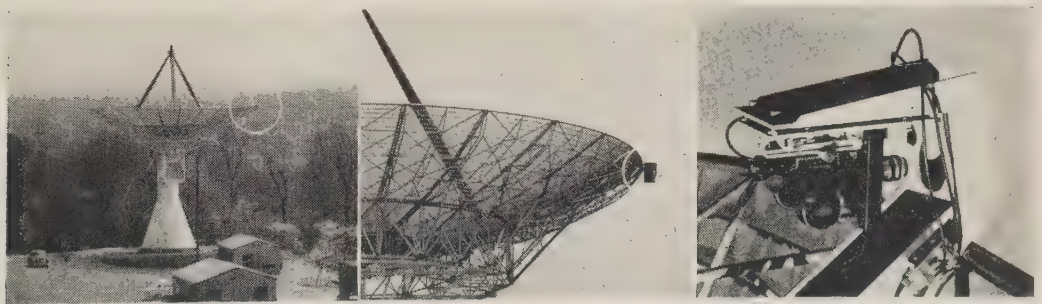


"shoots" satellites for Bell!

A pioneering step toward global communication was made by Bell scientists! An actual picture was transmitted ...from the Bell Telephone Laboratories' tracking station in Holmdel, New Jersey—to the Echo I satellite in space—to the Jodrell Band antenna in Manchester, England. ■ Arriflex is proud to have contributed to these advanced experiments in world communication. In Project Echo (involving a man-made satellite) and in the Moonbounce tests with a natural "sky mirror"—co-axially mounted Arriflex cameras dramatically documented correlation of radar tracking, compilation of azimuth and elevation of the radar dish, satellite position, and the elapsed time of the tracking period. ■ Why Arriflex? Because of its precise registration pin movement, advanced mirror reflex shutter system, and extreme versatility—and because all this is packaged in the most compactly designed professional camera. As always, Arriflex has done the job better, faster, more economically. On location, in the plant, in the laboratory, or in the studio—it can do the same for you!

The Arriflex-16 was actually mounted on the frame of the radar dish. A cross-hair reticle superimposed on the satellite picture verified the accuracy of radar positioning. Arriflex-collected data was of vital importance in checking all test apparatus and mapping out future projects.



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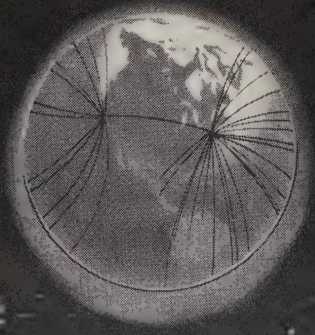


RCA The Most Trusted Name in Communications

No. 208 on Reader Service Card

SUB-MINIATURE AMPLIFIER for missile instrumentation

This sub-miniature amplifier, designed for missile instrumentation, is about the size of a penny match box. According to **Video Instruments Co., Inc., Dept. S/A, 3002 Pennsylvania Ave., Santa Monica, Calif.**, the model 96 contains a solid state amplifier, oscillator power supply, demodulator, and line voltage regulation. It is reported capable of raising millivolt signals from strain gages, bridge type pressure transducers, or bridge type accelerometers to a 5-volt level.

Output voltage can go from 0 to ±5 volts dc; frequency response is from 0 to 2000 cps. The unit can withstand accelerations of 50 g peak amplitude from 30 to 2000 cps and 100 g static acceleration. Operating temperature range is —55 to +165 deg F; primary power source is 28 volts dc.

No. 352 on Reader Service Card

TAPE-TO-CARD CONVERTER is solid state

This completely solid state tape-to-card converter is basically a block type reader and decoder. The complete system, developed by **Telecomputing Corp., Dept. S/A, 12838 Saticoy St., North Hollywood, Calif.**, consists of a type 55 converter and a standard IBM summary punch. Functional components include the block tape reader, a decoder, storage matrix, interlocking control relays, manual control, and a power supply.

Specifications include a speed of 100 cards per minute, block length of 22-44 digits, 5 to 8 channels, 11/16-, 7/8-, or 1-inch tape widths, 10-in. diameter storage reels, numeric coding, 105-120-volt, 60-cps ac power input.

No. 353 on Reader Service Card

RADIO SYSTEM for satellite signals

This radio receiving system is for picking up signals from a space satellite. It is said to be capable of locking exactly in phase with the radio frequencies transmitted by the satellite, according to the **Electronics and Ordinance Div., Avco Corp., Dept. S/A, Cincinnati 15, Ohio.** Each of its two large cabinets has three receivers and is tuned to 20, 40, 41, 108, 360, and 960 megacycles.

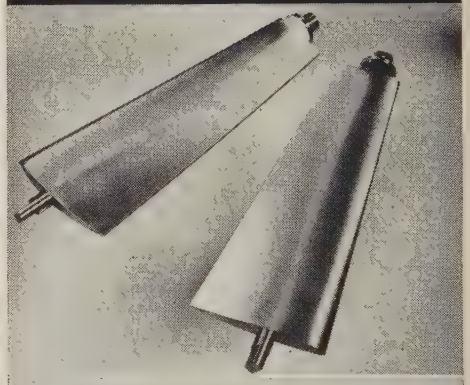
Each cabinet includes a power unit at the bottom, frequency synthesizers at top, plus tuning controls. Phase comparators will measure the relative delay or phase shift present between any two of the six frequencies transmitted by the satellite.

No. 354 on Reader Service Card

Stalker

lighter weight
lower cost
precision

SHEET METAL FABRICATIONS



Much time, effort and cost go into developing the processes necessary to produce satisfactory sheet metal fabrications. *The Stalker process has been PROVEN — with the production of many quality blades and vanes, as well as other brazed sheet metal assemblies.* Stalker Orthobrazed stainless steel or super-alloy fabrications — such as compressor and turbine blades — are *dimensionally and thermally stable.*

Produced to closer tolerances than the usual machined blades, nose radii of Stalker-produced blades feature a closer dimension and uniformity from blade to blade. The Stalker forming techniques also eliminate distortion during brazing and heat treat operations. Blades hold their precise shape because of the inherent thermal stability which insures Stalker quality. The Stalker quality control and inspection system is U.S.A.F. approved.

Stalker personnel, facilities and techniques are now available for the use of firms having precision sheet metal fabrication problems.

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No. 209 on Reader Service Card

DEMODULATOR-DETECTOR has many uses

This solid state demodulator/phase detector, which was initially designed for use in a ballistic missile guidance system, can also be used for data transmission, error sensing, servomechanism, and autopilot systems. Designated model 1806, the unit has several unique features such as small size, silicon diodes, low noise, low drift with temperature, and high shock and vibration capabilities, according to **Varo Mfg. Co., Inc., Dept. S/A, 2201 Walnut St., Garland, Tex.**

The completely encapsulated unit provides a dc voltage directly proportional to any amplitude/phase difference between the 35-volt, 800-cps reference input and the 0 to 25-volt, 800-cps signal input. A ring circuit of silicon diodes and precision components provide the dc output.

No. 355 on Reader Service Card

HEAT SINKS for transistors

Heat sinks for power transistors and diodes, designed for ease of mounting, are now available from **Invar Electronics Corp., Dept. S/A, 323 W. Washington Blvd., Pasadena, Calif.** Offering 25 sq in. of surface area for each inch of length, they provide a large heat dissipating surface, while maintaining minimum size.

These units may be used single or in multiple heat sink arrays, and are furnished with holes for mounting the heat sinks in compact array, and for attaching a terminal or resistor board to the heat sink. The electrically conductive finish meets MIL-C-5541. Special hole patterns and finishes can be furnished upon request.

No. 356 on Reader Service Card

MESA COMPUTER DIODE has high reliability

Nine hundred mesa computer diodes, types 1N914 and 1N916, randomly selected from normal production, are reported to have logged more than two million test hours under various environmental and operational conditions, without a single failure.

Despite severe testing limits of these components, **Texas Instruments, Inc., Dept. S/A, P.O. Box 312, Dallas 21, Tex.,** reports that only one unit has a reverse current reading of greater than 1.0 microamp dc. It is reported that this success assures that the diode will have a failure rate of better than 1×10^{-6} at the upper 95 per cent confidence limit.

No. 357 on Reader Service Card

In jeder Sprache, wo auch immer,
ist die Bedeutung die gleiche. Präzision oder Precision, als Wort und als Handelsmarke, ist der Schlüssel zu den höchsten Wertmasstäben in der Magnetbandaufzeichnung. Precision Bandgeräte bieten beispiellose Genauigkeit, Verlässlichkeit und Vielseitigkeit in der Aufzeichnung von wissenschaftlichen Daten und benötigen dennoch bei weitem weniger Platz, Strom und Fürsorge als gewöhnliche Bandgeräte. Fordern Sie Einzelheiten an—in jeder Sprache!
Vertreter erwarten Ihre Anfrage in allen grösseren Städten der Welt.

Quel que soit le lieu et l'idiome,
la définition est la même. Le mot, le marque Précision est synonyme des plus hauts standards d'opération en enregistrement sur bande magnétique. Les enregistreurs "Précision" offrent une exactitude, une sûreté et une souplesse hors-concours dans l'acquisition de données scientifiques. Pourtant les exigences d'encombrement, de puissance ou d'entretien sont moindre que des appareils d'enregistrement conventionnels. Demandez-nous des détails, en n'importe quelle langue!
Nos représentants sont établis à travers le monde.

In qualunque lingua, in qualunque luogo,
il significato è lo stesso. Precision, tanto la parola quanto il nome, è la chiave ai più alti gradi d'effettualità per registratori magnetici a nastro. I registratori Precision offrono esattezza impareggiabile, fidatezza, ed adattabilità nel registrare dati scientifici, però richiedono molto meno spazio, energia, e mantenimento che i registratori convenzionali a nastro. Chiedere per iscritto particolari—in qualunque lingua!
Rappresentanti si trovano nelle principali città del mondo.

In any language, anywhere,
the meaning is the same. Precision, both as a word and as a name, is the key to the highest standards of performance in instrumentation magnetic tape recording. Precision recorders offer unmatched accuracy, reliability, and flexibility in capturing scientific data, yet require far less space, power, or maintenance than conventional tape machines. Write for details—in any language!
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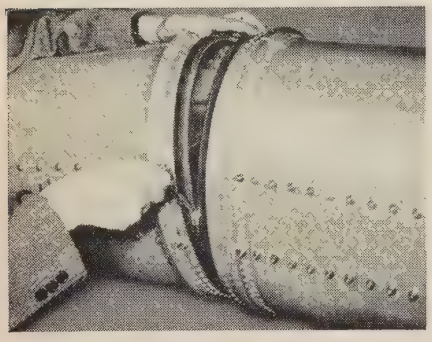
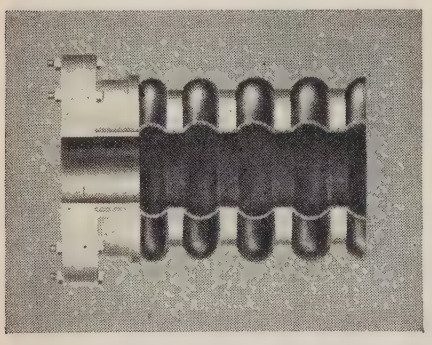
No. 210 on Reader Service Card

Ideas you can use from

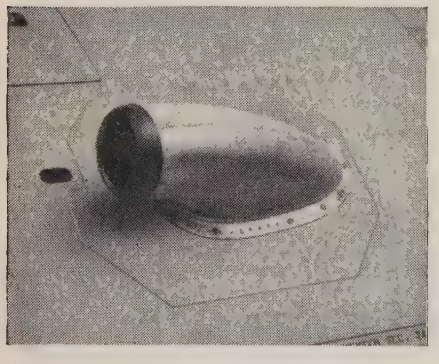
B.F.Goodrich



ZIPPERED DUCT SEAL. BFG zipper closures permit easy access to enclosed equipment such as this air duct. Seals effectively against liquids, gases, dust, dirt, corrosion. BFG zippers can be custom-fabricated for your product, or supplied as part of a complete closure.



FLEXIBLE FUEL-LINE CONNECTOR. Special flexible rubber joint reinforced with metal bands ideal for aircraft fuel line systems. These connectors serve as expansion and universal joints where loads and deflections are severe. Withstand bending and torsion —save weight.

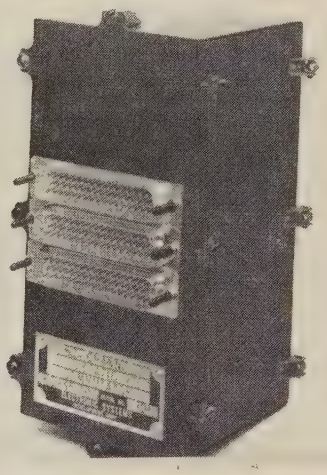


HEAT PACKAGE. BFG fabricates rubber shapes with integral electric heating elements for controlling ice formation in localized areas such as air intakes, cowls, propeller blades, spinners. Fabricated to fit perfectly to complex curves or odd shapes.

For more information check your B.F.Goodrich Aviation Products Representative, or write *Aviation Products, a division of The B.F.Goodrich Company, Dept. SA-8, Akron, Ohio.*

No. 211 on Reader Service Card

SOLID STATE COMMUTATOR provides time-sharing



This solid state switching device can sample data from multiple sources on a time-sharing basis, according to **Electronic Systems Development Corp., Dept. S/A, 1484 E. Main St., Ventura, Calif.** Extremely low noise levels and high resolution adapt the unit to the most critical applications, says the company. Output can be put on a single telemetry sub-carrier channel.

Input signal ranges of 0-10 mv or 0-5 volts are available, with crosstalk being only 0.1 per cent of the input signal. Linearity is within ±0.1 per-cent deviation from a straight line. Contact resistance is 25 ohm maximum.

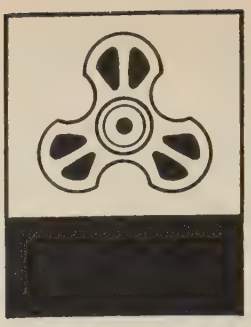
No. 358 on Reader Service Card

BROADBAND VIDEO DETECTOR is highly sensitive

The MA-441 broadband video detector diode is now available for high tangential sensitivity receiver use over the 40-75 kmc range. Minimum tangential signal sensitivity over the entire frequency range is –27 dbm for a bandwidth of 2.5 mc and 100 kc low frequency cutoff, says **Microwave Associates, Inc., Dept. S/A, South Ave., Burlington, Mass.** Smooth response without resonance power drop out ripples is reported achieved over the entire range.

A mica window seal in the detector waveguide prevents the entry of foreign matter. Waveguide connection permits use with ridged RG-98/U or with a taper for standard RG-97/U or RG-98/U waveguide. The diode and whisker are mounted across a section of ridged RG-98/U for best broadband response. All electrical conducting surfaces are silver plated throughout.

No. 359 on Reader Service Card



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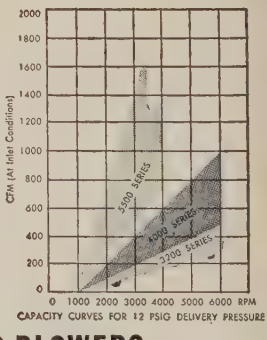
Exclusive M-D 3-lobe design adds strength—reduces torsion. Dynamically balanced rotor permits higher speeds —greater pressures.

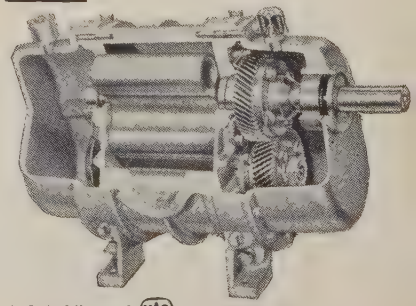
Why M-D rotary positive blowers develop higher pressures . . .

The unique combination of precision manufacture and modern design found only in M-D rotary positive blowers permits higher speed operation and higher pressures. For this reason M-D can furnish greater air flow at lower initial cost.

M-D blowers operate at wider pressure and speed ranges than any other rotary positive blower. Capacities of 30 production models range from 30 to 4,000 CFM, pressures to 15 PSIG single, 70 PSIG multi-stage.



M-D BLOWERS, INC.
RACINE, WISCONSIN



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Can you measure a movement several thousand times slower than the hour hand of your watch? With the skills of an expert organization behind you, could you design and develop your own test methods, equipments, and procedures? These would be for the evaluation of servo, gyro, and accelerometer performance and early prototype inertial systems, and would include precision voltage analog measurements. Write Mr. Donald Krause.

Qualified applicants will be considered regardless of race, creed, color or national origin.

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Woodland Hills, California

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Mr. Garrett Sanderson,
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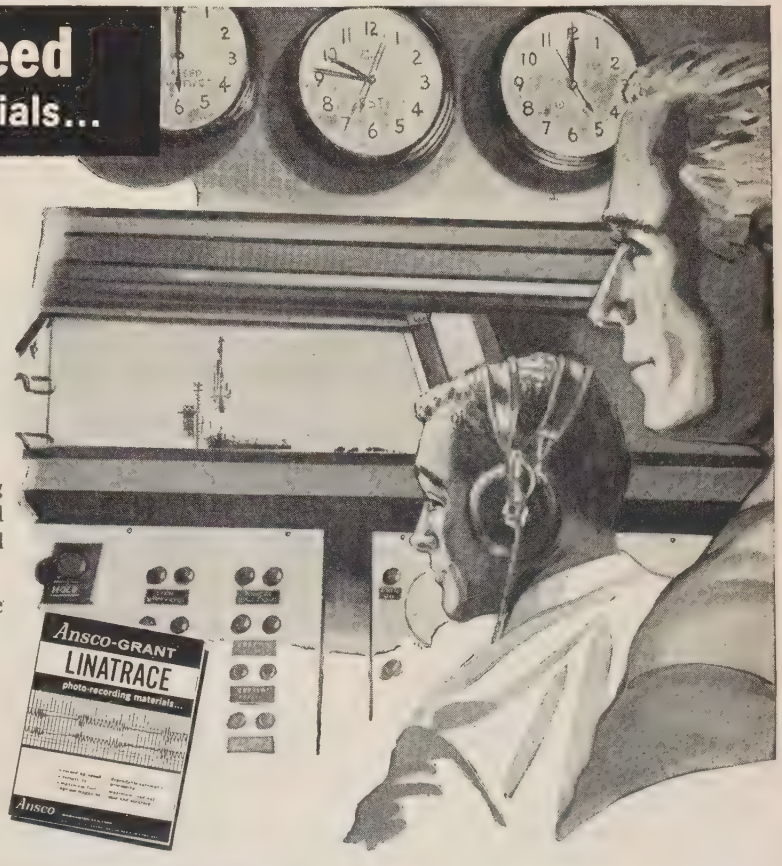

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DEPENDABILITY UNLIMITED
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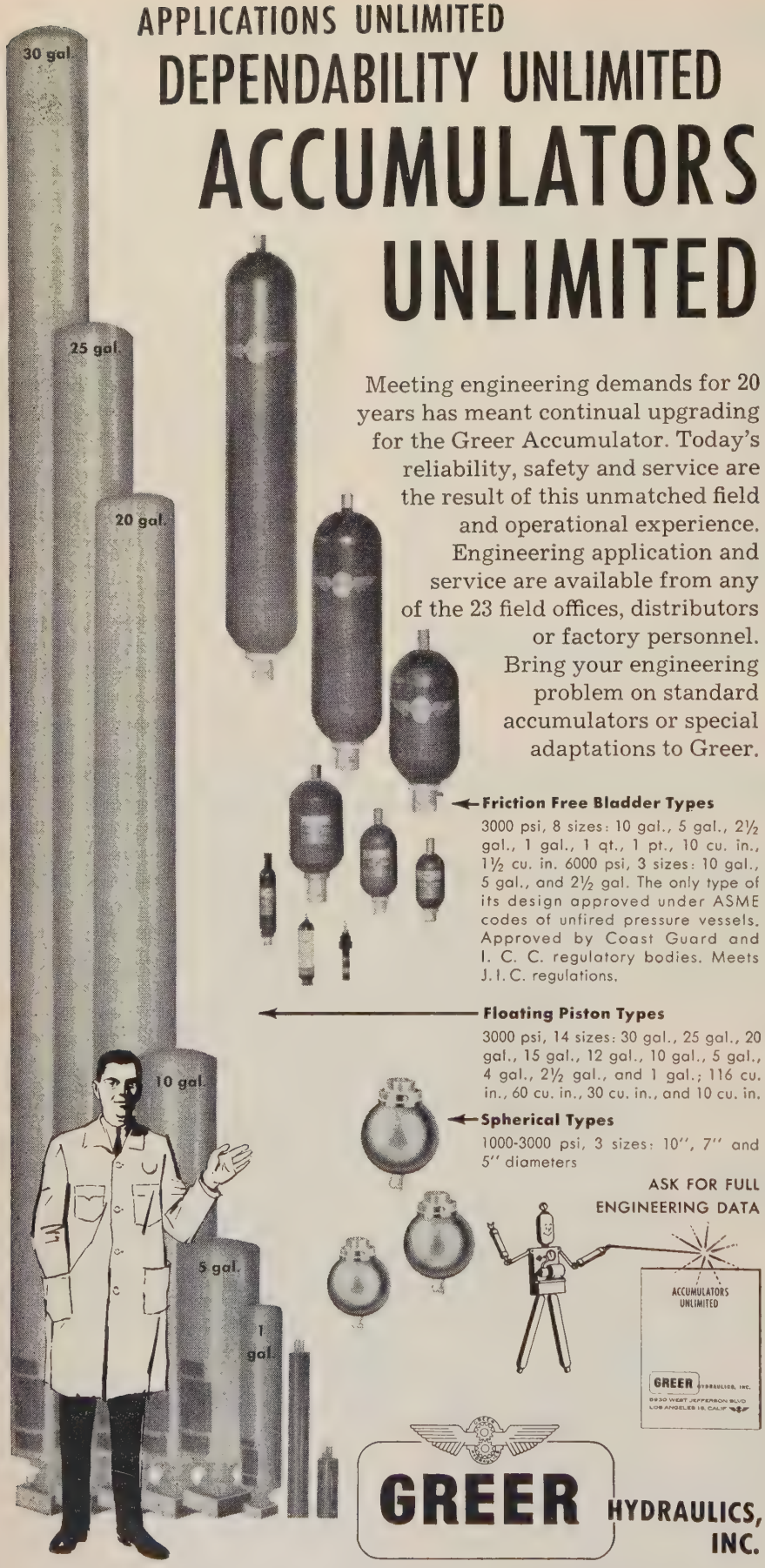

Friction Free Bladder Types
3000 psi, 8 sizes: 10 gal., 5 gal., 2½ gal., 1 gal., 1 qt., 1 pt., 10 cu. in., 1½ cu. in. 6000 psi, 3 sizes: 10 gal., 5 gal., and 2½ gal. The only type of its design approved under ASME codes of unfired pressure vessels. Approved by Coast Guard and I. C. C. regulatory bodies. Meets J.I.C. regulations.

Floating Piston Types
3000 psi, 14 sizes: 30 gal., 25 gal., 20 gal., 15 gal., 12 gal., 10 gal., 5 gal., 4 gal., 2½ gal., and 1 gal.; 116 cu. in., 60 cu. in., 30 cu. in., and 10 cu. in.

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1000-3000 psi, 3 sizes: 10", 7" and 5" diameters

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MICROWAVE MODULATOR is versatile

This high power model 10002 microwave modulator is designed to accommodate any of 76 magnetrons, covering 5400 to 35,000 mc, with peak outputs from 20 to 500 kw. The unit includes a high voltage power supply, pulse generator, meters, viewing connectors for all principal parameters, controls, and protective circuits, says **Narda Microwave Corp., Dept. S/A, 118-160 Herricks Rd., Mineola, N.Y.**

The use of silicon rectifiers results in compact packaging, and also ensures cooler operation. The high voltage supply is continuously variable from 0 to 9 kv at 200 ma, pulse power output is 37 kv at 40 amps max. The pulse generator is free running and continuously variable from 180 to 3000 pps. Standard pulse width is one microsecond. Safety provisions include automatic overload sensing, time delays and automatic sequencing and interlocks.

No. 360 on Reader Service Card

BROADBAND RF FILTER reduces interference

This RLC filter has its resistance and capacitance incrementally distributed throughout its inductive winding. The result is maximum RF attenuation with minimum loading, says **Devco, Inc., Dept. S/A, East Longmeadow, Mass.** Attenuation characteristics do not change with load. All units are fully shielded and hermetically sealed to comply with Mil-F-15733 and Mil-Std-202A.

Typically, the filter will attenuate interference 40 db at 1 Mc increasing to 80 db at 10 Mc and higher. Attenuation will remain above the 80 db level up to 4000 Mc. Units are available in 150- and 400-V DC ratings in two current ratings.

No. 361 on Reader Service Card

DATA SYSTEM for paper-to-tape conversion

This all solid state system extracts data from punched paper tape and writes it on magnetic tape. The model 1433 assures that input and output data are completely identical in content, according to **Tally Register Corp., Dept. S/A, 1310 Mercer St., Seattle, Wash.** The system will accept paper, foil or plastic tapes in widths varying from 5 through 8 level.

It can write data on magnetic tape in formats compatible with IBM 727, 729 Mod 1 and Remington Rand computer inputs. It will operate from standard power sources.

No. 362 on Reader Service Card

No. 214 on Reader Service Card

COUNTER MODULE offers reliability

This 1 kc decade counter module, model DC-113, utilizes the general purpose Beam-X TM switch (BX-1000). The plug-in module's input circuitry eliminates the necessity for tubes or transistors to activate succeeding decades, according to **Electronic Tube Div., Burroughs Corp., Dept. S/A, Box 1226, Plainfield, N. J.** The unit is designed to directly drive NIXIE indicator tubes, printers, and other devices without need for decoders or amplifiers.

No. 363 on Reader Service Card

FREQUENCY FILTER for low temperatures

A magnetostriction rod filter designed for 100 KC operation has been announced by the **Components Div., Raytheon Co., Dept. S/A, 55 Chapel St., Newton 58, Mass.** Model EM 3000 is used as a frequency standard in fixed frequency oscillators, sweeping-gate spectrum analyzers, and in various test equipments.

Operation range is from −60 deg to 80 deg C. In special tests it is said to have operated successfully after being dipped in liquid nitrogen, −193 deg. It is a low impedance device, readily adaptable for use with transistors. Its response characteristic is similar to a single-tuned circuit, falling off at 6 db per bandwidth octave.

No. 364 on Reader Service Card

TRANSFORMER is all encapsulated

This high-voltage specialty transformer features complete encapsulation of the windings in epoxy resin. Very low capacitance is said to be an additional feature which can be produced for operation either in air or in oil, according to **Components For Research, Inc., Dept. S/A, 979 Commercial St., Palo Alto, Calif.** Filament-isolation and high-voltage supply transformers and reactor chokes are being produced over the voltage range from 15 to 6000 va and with isolation to 300 kv.

In each type, the epoxy-resin construction provides constant electrical characteristics over a long service life and minimum size and weight for corona-free operation at rated high voltage, the maker says.

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WORKING PARTNERS

RCA 501 AND SOUNDCRAFT INSTRUMENTATION TAPES

For many corporations, the heart of their data handling operation will be the new RCA 501 Computer System. Soundcraft Tape proved to be the perfect working partner for the "501" — not only in the crucial testing of the computer, but afterward, in continuous working use.

Experience has proven that Soundcraft works best on leading computer systems, like the RCA 501. Why not let Soundcraft Instrumentation Tapes go to work for you. Complete literature on request.

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IT SEALS
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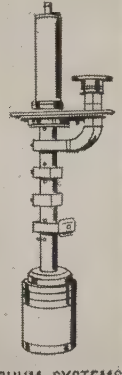
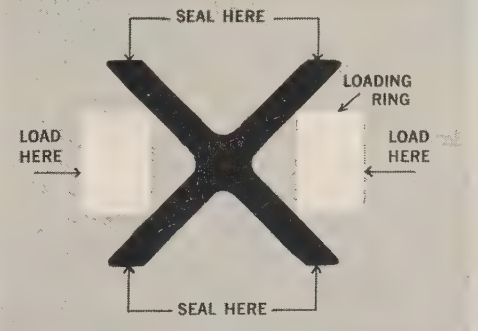

VACUUM SYSTEMS



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BAR-X-SIZES:
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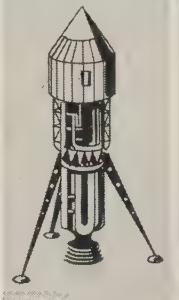
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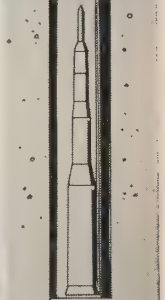
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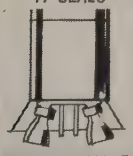
ROCKET ENGINES

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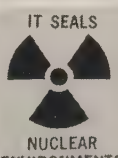
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Eliminates critical downtime ■ Very high and very low pressure ■ Easy, foolproof installation (not a mechanism) ■ All-metal—non-contaminating ■ Stable, symmetrical design

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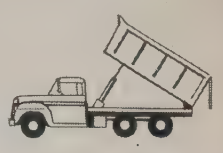
NO DOWNTIME FROM SEAL FAILURE

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*For dependable hydraulics . . . specify Kellogg**

Kellogg's expanding line of hydraulic pumps, fluid motors, valves, and systems provides exceptional reliability and performance for your hydraulic requirements. The unique design of the Kellogg variable stroke pump gives important inherent advantages. And Kellogg's design capability stands as a ready adjunct to your own engineering resources.

Kellogg pumps give: • Fast response. • High volumetric efficiency (over 95% at rated pressures). • Simplified design for maximum life, minimum maintenance. • Highest HP/weight ratio. • Dependable operation under rapid changes in acceleration, torque and thrust loads, and at elevated oil temperatures. • Minimum size. • Exceptional contamination tolerance.

For greater reliability in hydraulic components or systems, contact our engineering representatives, Airsupply-Aero Engineering Company, Division of The Garrett Corporation. Offices in major cities.

*Kellogg variable volume pumps range from 0.06 to 1.77 c.i.p.r., -65° to 450°F, to 5,000 psi, and to 18,000 rpm. Individual designs available for special requirements.

Variable Volume Pump Series	*Maximum Displacement Cu.In./Rev.*	*Weight Lbs.*	*Rated Speed*	*Max. Speed*	*AND Mounting Flange*
AP10V	1.77	17.5	3750	5000	10262
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AP4V	.67	10.0	6000	7500	10261
AP2V	.38	6.5	6000	8500	10261
AP1V	.2	4.5	8000	12000	10261
AP05V	.1	1.9	12000	15000	10261
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AMERICAN Brake Shoe COMPANY

A-6880

KELLOGG DIVISION • 3151 WEST FIFTH STREET • OXNARD, CALIF.

No. 217 on Reader Service Card

data preview

I-materials & production equipment

BALL WELDING—Bulletin CON-13 discusses manufacture of ball welded contact assemblies and is available from **Metals & Controls Inc., Dept. S/A, 34 Forest St., Attleboro, Mass.** The two-page bulletin includes detailed specifications, manufacturing capabilities, precious and non-ferrous base metals used, and results of typical bonds after welding.

No. 366 on Reader Service Card

TOOLING PLATES — Aluminum cast tool and jig plate or wrought tooling plate is the subject of a brochure issued by **Aluminum Company of America, Dept. S/A, Alcoa Bldg., Pittsburgh 19, Pa.** The eight-page brochure describes dimensional and physical tolerances, and metallurgical characteristics of three grades of aluminum.

No. 379 on Reader Service Card

CARBON-GRAPHITE — A technical bulletin describing the properties and qualities of various grades of carbon and graphite is available from **Speer Carbon Co., Dept. S/A, St. Mary's, Penna.** Entitled "Carbon and Graphite for High Temperature Applications" it describes applications in machining molds, dies, crucibles and other items that require resistance at high temperatures, and includes a chart listing various types and grades available, their size, and their physical and chemical properties.

No. 367 on Reader Service Card

PLASTIC MOLDING—A 16-page brochure describing the custom plastic molding facilities at its Taunton Div. has been prepared by **Haveg Industries, Inc., Dept. S/A, Plastics Park, Wilmington 8, Del.** The publication discusses elastometer and foam production, Havelex, injection molding, compression and transfer molding, sealing caps and tubes, tooling and quality control, and also includes a plastic materials comparison chart which gives the major advantages of various thermosets and thermoplastic resins along with their physical, mechanical and electrical properties.

No. 368 on Reader Service Card

PLASMA SPRAY—Bulletin 6114 discusses advances in plasma spray coating for space materials and is available from **Systems Management Div., Western Gear Corp., Dept. S/A, P.O. Box 182, Lynwood, Calif.** The eight-page bulletin describes applications of plasma spray to a wide range of space materials from aluminum to zirconium and covering such space parts as re-entry bodies, rocket engine nozzles, and nuclear components.

No. 369 on Reader Service Card

TITANIUM—A 14-page brochure entitled "Titanium for Missiles" which describes and illustrates major application areas for titanium is available from **Titanium Metals Corp. of America, Dept. S/A, 233 Broadway, New York 17, N. Y.** The brochure includes a discussion of the four titanium alloys of greatest significance in missile applications, pertinent cost data, and a synopsis of applications to pressure vessels for liquid rockets, and solid rocket casings.

No. 370 on Reader Service Card

LOCK NUTS—A new catalog describing its complete line of self-locking nuts has been issued by **Kaylock Div., Kaynar Mfg. Co., Inc., Dept. S/A, Box 2001, Terminal Annex, Los Angeles 54, Calif.** The catalog features a new line of floating and non-floating stakenuts in various sizes, and a new line of high-strength thin wall inserts.

No. 371 on Reader Service Card

CERAMICS—Ceramics Chart No. 611 describing the mechanical and electrical properties of ceramics has been issued by **American Lava Corp., Dept. S/A, Chattanooga 5, Tenn.** The chart includes graphs of thermal expansion, dielectric strength, volume resistivity, and a ceramics selection chart.

No. 372 on Reader Service Card

METAL FINISHING—A new 12-page brochure entitled "Specialized Chemical Processing Compounds for the Metalworking Industry" is available from **Turco Products, Inc., Dept. S/A, 24600 S. Main St., Wilmington, Calif.** The brochure describes 43 products and application to such chemical processes as; cleaning, phosphating, conversion coatings, protective coatings, descaling, rust removing and prevention.

No. 373 on Reader Service Card

SILVER BRAZING—A revised 24-page brochure entitled "Aircosil Silver Brazing Manual" has been issued by **Air Reduction Sales Co. Div., Air Reduction Co., Inc., Dept. S/A, 150 East 42nd St., New York 17, N. Y.** Manual 847 C describes brazing procedures, problems and solutions. All Aircosil silver brazing alloys, including the new Fluxcor 45 which incorporates the fluxing agent in the center of the wire, are described, stressing advantages and applications.

No. 374 on Reader Service Card

RADIATION SERVICES — The capabilities for investigation of nuclear effects on materials and components are described in a folder prepared by the **Marquardt Corp., Dept. S/A, 16555 Saticoy St., Van Nuys, Calif.** The publication, MP 829, discusses the facilities of the Radiation Effects Laboratory.

No. 375 on Reader Service Card

SILICONES—A comprehensive booklet on silicones providing the most recent and advanced information has been issued by the **Silicones Div., Union Carbide Corp., Dept. S/A, 270 Park Ave., New York 17, N. Y.** It provides charts of the properties and features, discusses applications, and lists technical information.

No. 376 on Reader Service Card

PANEL FASTENERS—A 6-page brochure that describes the self-aligning and locking features of P series floating captive bolts has been issued by **Hi-Shear Corp., Dept. S/A, 2600 W. 247 St., Torrance, Calif.** The brochure covers applications, dimensions, material specifications, test data, and installation methods.

No. 377 on Reader Service Card

CARBON-GRAPHITE—An eight-page engineering bulletin discussing carbon-graphite materials for mechanical applications is available from **National Carbon Co., Dept. S/A, 270 Park Ave., New York 17, N. Y.** Bulletin S-5425 includes grade recommendations for seals and sliding surfaces for a wide range of liquids and gases above 500 deg F and in the cryogenic range, and tabular data on 18 grades of carbon, graphite, carbon-graphite for applications such as bearings, bushings, and seals.

No. 378 on Reader Service Card

RPI space age support provides . . .

FASTEST DELIVERY OF

LOW COST ROCKET MOTORS

For "off-the-shelf" availability, RPI provides *prompt delivery* on a wide variety of low-cost, versatile rocket motors. A complete inventory of parts and ready supply of loaded motors is always maintained.

What's more, RPI motors have a perfect record of *operational success* over many hundreds of firings. The same quality control is applied to *all* motors whether for manned or unmanned flight . . . for drone or missile boost, missile propulsion, target or sounding rockets, ejection, deceleration or recovery systems.

STANDARD ROCKET MOTORS

Type	Length and Diameter (inches)	Weight Loaded (pounds)	Total Impulse (sea-level) (lb sec)
Miniature	5.3 x 1.0	0.3	14
PIKI I	15.8 x 4.4	16.9	1,115
JUDI I	66.0 x 3.0	23.8	3,900
PIMA I	33.4 x 5.6	48.8	6,030
HOPI I	80.4 x 4.5	74.4	11,900
KISHA I	72.1 x 6.5	145.0	21,300
KIVA I	106.7 x 6.5	216.0	33,500
GILA III	101.6 x 9.0	396.0	65,500

FOR TECHNICAL DATA on any of these motors, write for Technical Bulletin #1400.

ROCKET POWER INC.

FALCON FIELD/MESA, ARIZONA

OFFICES: Pasadena/Dayton/Washington, D.C.

No. 218 on Reader Service Card

DATA PREVIEW

PLASMA SPRAY—A 12-page brochure discussing the plasma spraying process is available from **Plasmatech Div., Valley Metallurgical Processing Co., Dept. S/A, Essex, Conn.** The brochure describes the plasma torch, surfaces that can be coated, design considerations, and general advantages of plasma coatings.

No. 380 on Reader Service Card

SILICONE RUBBER—A silicone rubber selector chart, CDS-145C, is available from the **Silicone Products Dept. General Electric Co., Dept. S/A, Waterford, N. Y.** It is designed to assist designers and engineers, and contains comprehensive data on applications, typical properties, primary classes and specifications.

No. 381 on Reader Service Card

ELECTRICAL RESINS—A product information folder on electrical resins has been prepared by **Minnesota Mining and Mfg. Co., Dept. S/A, St. Paul 6, Minn.** The folder contains temperature curves, application information, viscosity characteristics, processing information, and general technical data.

No. 382 on Reader Service Card

RARE EARTHS—A revised 1961 edition of an eight-page brochure containing technical information on thorium, yttrium chemicals, metals and alloys of the rare earth group of elements is available from the **Vitro Chemical Company, Dept. S/A, 342 Madison Ave., New York 17, N. Y.** It contains information on potential uses, describes manufacture, and lists detailed properties and chemical analysis of more than fifty products.

No. 383 on Reader Service Card

RUBBER PRODUCTS—Catalog M5 covers the complete line of rubber products for industry available from **Manhattan Rubber Div., Raybestos-Manhattan, Inc., Dept. S/A, Passaic, N. J.** It includes data on transmission and conveyor belts, hose, pipe and expansion joints, and molded and extruded parts.

No. 384 on Reader Service Card

PLASTIC MATERIALS—A 12-page bulletin entitled "Narmco Materials for Rockets and Missiles" is available from **Narmco Materials, Dept. S/A, 600 Victoria St. Costa Mesa, Calif.** This bulletin describes and illustrates application of such plastic products as structural adhesives, ablative and insulating compounds, and multiwave sandwich core.

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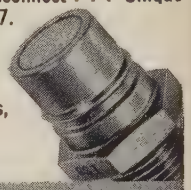
TRIGGER QUICK

FINGER-TIP OR LANYARD RELEASE

FAST EASY POSITIVE

New Symetrics 500 Series Disconnects (3000 psi) offer these famous Symetrics features: Lightest weight . . . smallest envelope . . . zero leakage during disconnect . . . no air inclusion during connect . . . Full pressure and no exposed seals after disconnect . . . Unique design exceeds MIL-C-25427. Other models available in plastic and special materials. For information on other Symflow Disconnects, write to:



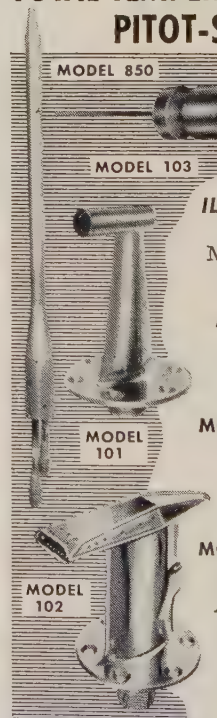
SYMETRICS COUPLINGS

SYMETRICS, INC.

2919 NEBRASKA AVENUE, SANTA MONICA, CALIF.

No. 219 on Reader Service Card

TOTAL TEMPERATURE PROBES PITOT-STATIC TUBES



ILLUSTRATED MODELS

MODEL 850 Meets Mach 3 requirements of MIL-P-25757A (USAF).

MODEL 103 Mach 5 total temperature probe can be used to temperatures of 1500 C°.

MODEL 101 Mach 3 total temperature probe. Meets requirements of MIL-P-25726 (USAF).

MODEL 102 Mach 3 Deiced total temperature probe. Accurately measures total temperature during deicing.

Write for Short Form Catalog No. 66030

REC

ROSEMOUNT ENGINEERING COMPANY

4912 West 78th St. Minneapolis 24, Minn.

No. 220 on Reader Service Card

DATA PREVIEW

MACHINABLE CARBIDE—Technical data and typical applications of Ferro-Tic, a steel bonded, heat treatable carbide are given in this 12-page brochure available from **Sintercast Div., Chromalloy Corp., Dept. S/A, 169 Western Highway, West Nyack, N. Y.** It also gives processing instructions for machining, joining, hot forming, and heat treating.

No. 386 on Reader Service Card

FASTENERS—A 64-page catalog of detailed and descriptive information about fasteners has been prepared by the **Elastic Stop Nut Corp. of America, Dept. S/A, Union, N. J.** It is profusely illustrated and contains specification tables, diagrams, and extensive application data.

No. 387 on Reader Service Card

PLASTICS—This 12-page catalog on the company's line of polycarbonate resins, phenolic resins, varnishes, molding powders, and fused magnesium oxide is available from the **Chemical Materials Dept., General Electric Co., Dept. S/A, 1 Plastics Ave., Pittsfield, Mass.** The catalog has been compiled as an aid to designers, molders, fabricators, and end-users.

No. 388 on Reader Service Card

PLASTIC CONTAINERS—Glass filament wound container structures are the subject of a brochure issued by **Zenith Plastics Div., Dept. S/A, 1600 West 135th St., Gardena, Calif.** The 12-page brochure describes missile containers for shipment and storage, materials, quality, and facilities.

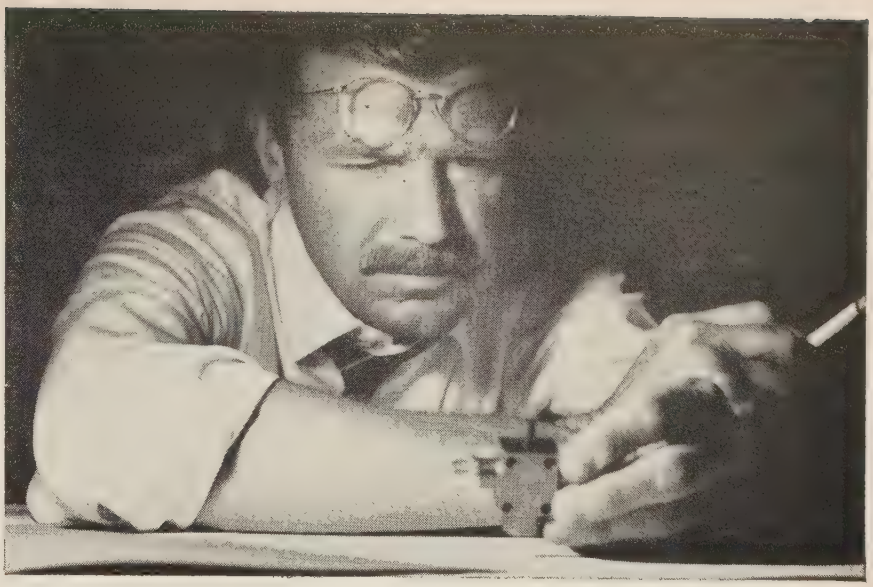
No. 389 on Reader Service Card

CORROSION—Various kinds of corrosion and the different metals suited to resist them are reviewed in detail in a 24-page illustrated brochure, "Corrosion Guide," available from **H. M. Harper Co., Dept. S/A, Morton Grove, Ill.** The guide lists 136 types of corrosive agents and how well each of eight types of metals resist each.

No. 390 on Reader Service Card

MACHINING CHART—A two-page stainless steel machining chart Sec. A, No. 5 describing recommended machining rates for 37 types of stainless steel has been prepared by **Peter A. Frasse & Co., Inc., Dept. S/A, 17 Grand St., New York 13, N. Y.** Ten separate machining operations, with specific tooling data, have been condensed for quick reference, and turning rates are detailed for various types of lathe. Also included is a table of RPM versus surface ft per min.

No. 391 on Reader Service Card



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CABLE CONTROL SENSITIVITY

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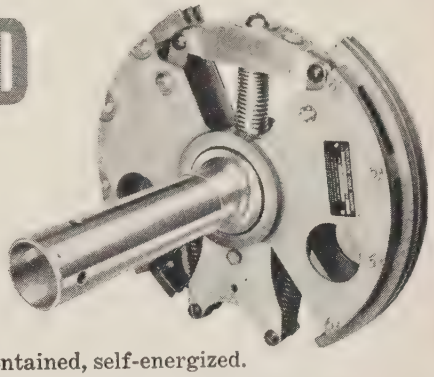

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They provide steady and uniform control response—instant compensation for thermal and/or mechanical variations and dependable performance under all flying conditions.

The performance of Pacific Scientific cable tension regulators in Lockheed's C-130 Hercules prop-jets has been so completely reliable that they were also chosen for the new Jetstar.

Models are available, or can be developed to meet any cable control system need.

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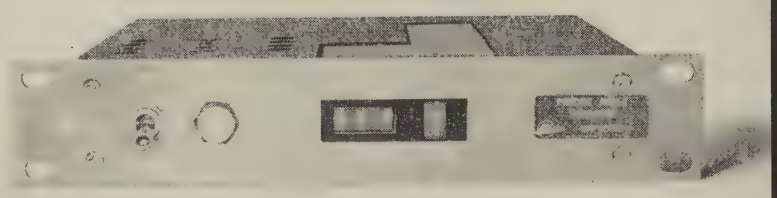


HIGH-ACCURACY PRECISE ANGLE INDICATOR

NEW KEARFOTT UNIT ACCURATE TO ±6 MINUTES

The new CO 2721011 Precise Angle Indicator features an accuracy of ±6 minutes. Latest addition to the Kearfott line of standard test equipment, the unit is designed to meet a wide range of applications. Typical Applications • Indication of gyro angle of pitch, roll, or yaw and relaying of signal to any preselected impedance or voltage level. • Indication of shaft position of remote synchro or resolver, and transmission of this information to any impedance or voltage level. • Display of difference between two shafts when driven by transmitter and differential synchros.

In addition to high accuracy the instrument combines a number of other prominent advantages: it requires only a single power source; it has good sensitivity; it is designed for modular application; and it offers direct automatic read-out. The unit is of extremely compact construction and is built for maximal ease of maintenance.

The low-cost CO 2721011 Precise Angle Indicator is available with a single sensor, auxiliary dual-input sensor, or an auxiliary retransmitter. For additional information on this new test instrument, write for the brochure which describes its operation and capabilities in detail.

SPECIFICATIONS

Repeatability	±1.2 min	**Slewing Speed**	7 sec/180°
Readability	0.5 min	**Power (single source)**	115 v, 1φ, 400 cps
Input Power	30 va	**Size**	1¾ x 9½ x 9⅛ in.
Sensitivity	1.0 min	**Weight**	4 lbs.

Write for complete data

KEARFOTT DIVISION
GENERAL PRECISION, INC.

Little Falls, New Jersey

SOCKET HEAD SCREWS — Socket head cap screws are illustrated and discussed in a 4-page bulletin, Form 2707, issued by the **Industrial Fastener Div., SPS, Dept. S/A, Jenkintown, Pa.** It provides dimensions and application data, fatigue and torque curves, and other technical information.

No. 392 on Reader Service Card

BRAZING—An eight-page brochure describing dip brazing aluminum fabrication techniques is available from **Precision Dipbraze, Inc., Dept. S/A, 12031 Vose St., North Hollywood, Calif.** The brochure discusses the advantages of the dip braze method for joining aluminum segments into intricate assemblies, and factors to be considered for assembly by dip brazing.

No. 393 on Reader Service Card

II-accessory equipment

PRECISION CONTROL—A 6-page folder entitled "Precision Products for Precision Control" is available from **Bowmar Instrument Corp., Dept. S/A, 8000 Bluffton Rd., Fort Wayne. Ind.** The folder illustrates representative devices and provides general technical data and descriptions.

No. 394 on Reader Service Card

SPECIAL MOTORS—Special purpose motors are the subject dealt with in a pamphlet available from **Kollsman Motor Corp., Dept. S/A, Mill St., Dublin, Pa.** It offers a description of the facilities of the company.

No. 395 on Reader Service Card

SWITCHES—A 6-page folder describing acceleration switches has been published by **Donner Scientific Co., Dept. S/A, Concord, Calif.** It provides graphs, specifications, and general and technical information.

No. 396 on Reader Service Card

RUBBER SEALS—A 42-page catalog containing technical information on rubber seals which are especially suitable for the aircraft industry has just been issued by **Connecticut Hard Rubber Co., Dept. S/A, 407 East St., New Haven 9, Conn.** It features design information on a wide variety of seals, in addition to covering materials, properties, and variations in construction.

No. 397 on Reader Service Card

No. 223 on Reader Service Card

MECHANICAL CONTROLS—A line of mechanical controls for aircraft, missile and nuclear energy fields is described in Bulletin EB-1160 published by **Eanco, Inc., Dept. S/A, 2701 N. Broad St., Philadelphia 32, Pa.** It discusses materials, features, and applications.

No. 398 on Reader Service Card

CANNED PUMPS—A four-page bulletin describing a series of Chempumps has been made available by the **Chempump Div., Fostoria Corp., Dept. S/A, Huntingdon Valley, Pa.** Bulletin 2050 also includes performance curves and a detailed cross-section of the canned pumps.

No. 399 on Reader Service Card

HYDRAULIC FILTERS — Aircraft hydraulic filters are described and discussed in Bulletin A7 prepared by **Aircraft Porous Media, Inc., Dept. S/A, Glen Cove, N. Y.** It provides detailed information, technical data, diagrams, drawings, and other illustrations.

No. 400 on Reader Service Card

RATE GYRO—A product data sheet, 116-11, describing a subminiature rate gyro has been published by **Lear Instrument Div., Lear, Inc., Dept. S/A, 110 Ionia Ave., N. W., Grand Rapids 2, Mich.** It contains engineering data, features, schematic and installation diagrams and drawings and a curve of damping characteristics.

No. 401 on Reader Service Card

HOSE AND DUCTS—Industrial prices and general data on flexible hose and ducts for moving air, dust, fumes, and materials using pressure, suction, or gravity, are covered in this bulletin prepared by **Flexaust Co., Dept. S/A, 100 Park Ave., New York 17, N. Y.** The bulletin also contains selection and installation data.

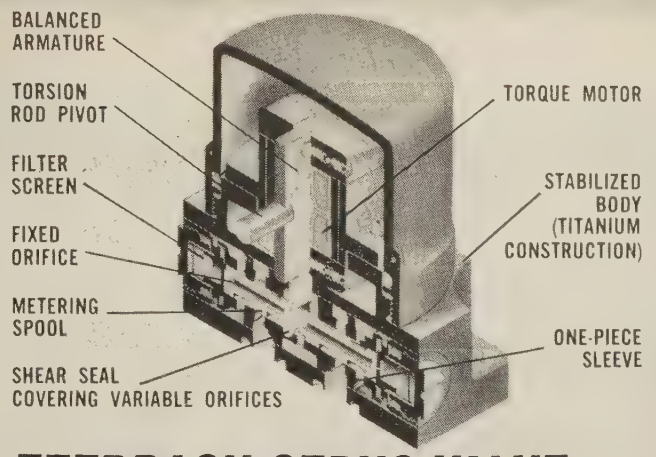
No. 402 on Reader Service Card

BEARINGS — Self-aligning bearings and rod end bearings are illustrated and described in detail in a 56-page catalog, No. 551, published by **Southwest Products Co., Dept. S/A, 1705 S. Mountain Ave., Monrovia, Calif.** It provides information on materials and other technical information.

No. 403 on Reader Service Card

SENSORS—Glass electrode carbon dioxide sensors are discussed in a 4-page folder available from **Beckman Instruments, Inc., Dept. S/A, 2500 Harbor Blvd., Fullerton, Calif.** Bulletin, CS-60-1006 gives information on applications, presents charts and curves and related technical data.

No. 404 on Reader Service Card



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- Unity coupled Hydromechanical Feedback
- High Null Accuracy ■ Only 2 moving parts
- Large, full opening, shear-seal orifices

This two-stage, four-way flow control valve is the only one available that provides true positional feedback without springs or levers. The first stage consists of an electrical torque motor and "shear-seal" orifice hydraulic amplifier, while the second or control stage is made up of an accurately matched spool and sleeve arrangement.

Hydromechanical unity feedback relates spool position to torque motor armature position and also nulls out effects of orifice variations due to supply pressure and temperature fluctuations. Flow force reactions are thus substantially reduced and hydraulic centering of pilot position is feasible without spring hysteresis and null shift. Large orifices prevent clogging and silting and high shear forces permit efficient operation even with highly contaminated fluids. Final null adjustments are made electrically by a balancing control at amplifier output stage.

TYPICAL CHARACTERISTICS

	Medium Flow (#6103-#6106)	High Flow (#6104)
Rated flow	to 7.5 gpm at 3000 psi valve pressure drop	to 18.0 gpm at 3000 psi valve pressure drop
Hysteresis	3% maximum total rated current	3% maximum total rated current
Supply pressure	300 to 3000 psi	300 to 4000 psi
Proof pressure	4500 psi pressure port 3000 psi return port	6000 psi pressure port 3000 psi return port
Pressure gain	First stage—500 psi per ma minimum with 3000 psi supply	First stage—500 psi per ma minimum with 3000 psi supply
Load pressure gain	.8500 psi per ma minimum with 3000 psi supply	10,000 psi per ma minimum with 3000 psi supply
Temperature	—65°F to +275°F	—65°F to +275°F
Maximum Null Shift Temperature Change per 100°F	(% of rated current) 1%	1%
Supply Pressure Variation ±	2%	2%
Quiescent Current Change 20%	1%	1%
Weight	12 ounces	16 ounces

TORQUE MOTOR: Note: 6103 & 6106 Identical with exception of torque motor characteristics.

	Valve #6103	Valve #6106
Input Power	300 Milliwatts	64 Milliwatts
Rated Current	± 10 ma	± 8 ma
DC Coil Resistance (other motors also available)	3000 ohms/coil	1000 ohms/coil

Write for complete data

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Little Falls, New Jersey

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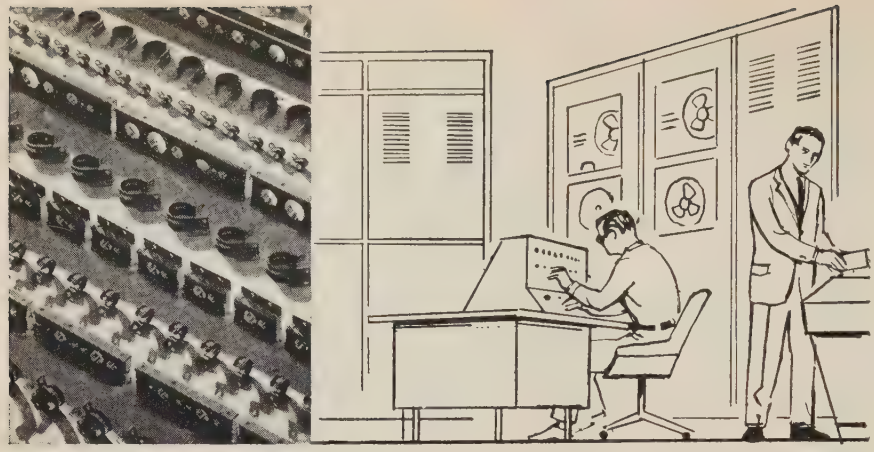

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No. 225 on Reader Service Card

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No. 226 on Reader Service Card

DATA PREVIEW

CONTROLS—A new 66-page catalog entitled "Controls for Flight" describing their line of aerospace controls has been issued by **United Control Corp., Dept. S/A, 4540 Union Bay Place, Seattle 5, Wash.** The catalog illustrates and describes the technical features of flight and propulsion controls, environmental controls, temperature controls, and accessory systems and components.

No. 405 on Reader Service Card

TIMING UNITS—A condensed catalog on its timing motors and time and torque controls is available from **Haydon Div., General Time Corp., Dept. S/A, Torrington, Conn.** It includes data on dimensions and design characteristics.

No. 406 on Reader Service Card

ACTUATION — An engineering data book entitled "Ball Bearing Screw and Spline Operation" is available from **Actuator Operation, Saginaw Steering Gear Div., General Motors Corp., Dept. S/A, Saginaw, Mich.** The 24-page publication provides basic principles, types, and applications, as well as design data, and other technical facts.

No. 407 on Reader Service Card

SNAP-ACTION SWITCHES — Precision snap-action switches are discussed in a 32-page catalog prepared by **Licon Div., Illinois Tool Works, Dept. S/A, 6606 W. Dakin, Chicago 34, Ill.** It provides ratings, dimensions, switch life, and operating characteristics.

No. 408 on Reader Service Card

MULTIPLE CONNECTORS — One-piece and two-piece multiple connectors for printed circuit boards are described in a six-page folder published by **AMP Inc., Dept S/A, Harrisburg, Pa.** It provides details of the features, line drawings for the "snap-in" contacts, and cut-away drawings of housings available.

No. 409 on Reader Service Card

SOLENOID VALVE—A solenoid operated 2-way coaxial shut-off valve is the subject of Bulletin No. 401 available from **Weatherhead Co., Special Products Div., Dept. S/A, Cleveland 8, Ohio.** It contains engineering data and other technical information.

No. 410 on Reader Service Card

BEARINGS—A technical bulletin on Reali-Slim ball and roller bearing designs is available from **Kaydon Engineering Corp., Dept. S/A, Muskegon, Mich.** Detailed information is given on performance, applications, and design features.

No. 411 on Reader Service Card

DIAPHRAGMS—Elastometer-fabric diaphragms is the subject of a four-page brochure by **Diaphragm Industries, Inc., Dept. S/A, 102 Rantoul St., Beverly, Mass.** The brochure describes long stroke, rolling, pre-convoluted, and molded convolution diaphragms for applications in aircraft and industry.

No. 412 on Reader Service Card

RELAYS — A 6-page technical bulletin on wedge action, six-pole, double-throw relays is available from **Electro-Tec Corp., Dept. S/A, 10 Romanelli Ave., So. Hackensack, N. J.** It describes the wedge action operation and lists design features and performance data.

No. 413 on Reader Service Card

MOTOR-GENERATOR — A brushless inductor motor-generator is the subject of a pamphlet, IMG30-860, published by **Leach Corp., Dept. S/A, 18435 Susana Rd., Compton, Calif.** It provides technical information, including specifications, design features, and other data.

No. 414 on Reader Service Card

ROTARY SWITCH — Data sheet #184, dealing with construction, characteristics and electrical rating of a rotary actuated "HR" hermetically sealed switch, is available from **Micro Switch Div., Minneapolis-Honeywell Regulator Co., Dept. S/A, Freeport, Ill.** It includes dimension drawings, charts, photographs, and other technical information.

No. 415 on Reader Service Card

ROD ENDS—Rod ends and spherical bearings are described and discussed in a catalog, #101, published by the **Split Ballbearing Div., MPB, Inc., Dept. S/A, Lebanon, N. H.** It provides dimension tables and drawings and other technical information.

No. 416 on Reader Service Card

ORDNANCE DEVICES — Explosive-actuated devices are described in a catalog prepared by **Lockheed Electronics Co., Dept. S/A, 6201 E. Randolph St., Los Angeles 22, Calif.** Included are specification sheets for several products.

No. 417 on Reader Service Card

TEMPERATURE REGULATORS—Temperature regulating devices for holding air or liquid temperatures within fractions of a degree are described in illustrated Catalog 360, released by **American Instrument Co., Inc., Dept. S/A, 8030 Georgia Ave., Silver Spring, Md.** The range of devices includes bimetal and mercury thermoregulators, heaters, relays, stirrers, pumps, and transformers.

No. 418 on Reader Service Card

JACKETED "Y" GLOBE VALVES for CRYOGENIC SERVICES

Fig. No. 710Y JC 10K

Manual Handwheel Operator

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FEATURES

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- √ Choice of Insulation: Foam, Vacuum, or Gas-Filled Powder
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Genisco's 931 Series G-Accelerators feature crystal-controlled oscillator to hold allowable drift to .001% from angular velocity of main rotating arm or outboard table . . . Calibration speeds preset to customer specifications within .5 to 30 g range . . . Direct-coupled synchronous drive motors . . . Loading maximums: 25 lbs. fixed platform; Model available with 10 lbs. outboard table . . . Varied modes including sinusoidal or spatial orientation.

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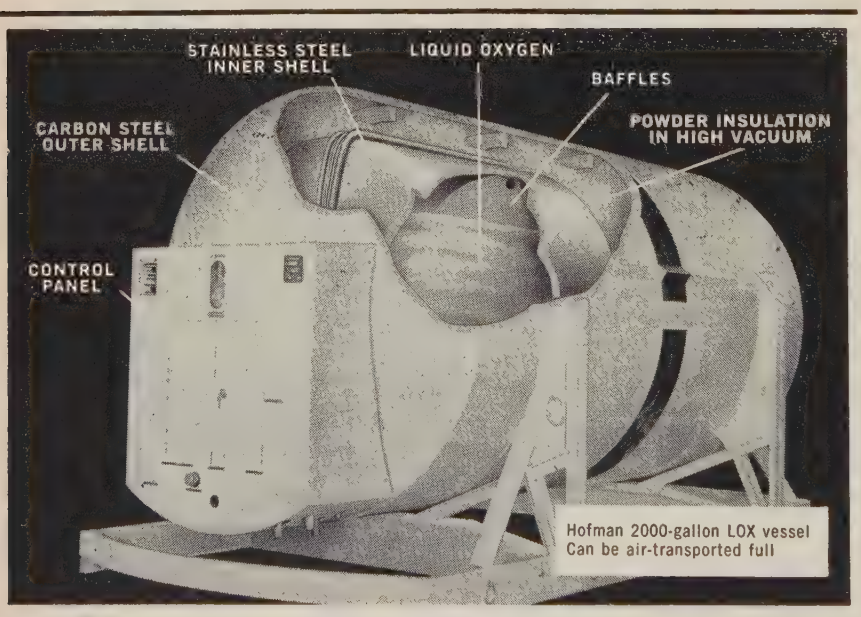

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No. 229 on Reader Service Card

DATA PREVIEW

DIAPHRAGM SEALS – Selection and application of rolling diaphragm seals for hydraulic and pneumatic actuators, controls, and specialized devices are discussed in a 28-page manual, BF-400-A, issued by **Bellofram Corp., Dept. S/A, 50 Blanchard Rd., Burlington, Mass.** The manual covers materials, designs, sketches, formulae, and other technical matters.

No. 419 on Reader Service Card

CONTROLS—Transistor circuits and thermistor sensing elements are among the features of four new temperature controllers described in Bulletin MC-190, now available from **Fenwal, Inc., Dept. S/A, Ashland, Mass.** Detailed specifications are given for the 536 non-indicating controller, the 561 indicating, the 582 thermometer, and the 580 indicator accessory for the 536 unit. Various options which may be obtained are described in the brochure, and sketches are included for various applications.

No. 420 on Reader Service Card

ACCELEROMETERS – Technical Bulletin T-105 is available from **Columbia Research Laboratories, Dept. S/A, MacDade Blvd. & Bullen Lane, Woodlyn, Penna.** The bulletin covers a line of eight compressor type accelerometers. Specifications and prices are quoted for the different models.

No. 421 on Reader Service Card

SERVO MOTORS – A data file on standard and BuOrd Mark series servo motors has been released by **Rotating Components, Inc., Dept. S/A, 267 Green St., Brooklyn 22, N. Y.** Information is supplied on size 11, 15, and 18 motors, as well as on special designs. New data sheets will be issued periodically to keep the file up-to-date.

No. 422 on Reader Service Card

RATE GYROS—A 55-page booklet on gyro angular velocity sensors is available from **Aircraft Instrument Div., R. C. Allen, Dept. S/A, 333 Commerce Ave., S. W., Grand Rapids, Mich.** It covers theory, applications, testing, and terminology.

No. 423 on Reader Service Card

COUPLINGS—Basic valving and connection principles of Quick Disconnect Couplings are contained in an 8-page bulletin, #254, available from **Aeroquip Corp., Dept. S/A, Jackson, Mich.** Prepared for design engineers, the booklet summarizes the advantages and limitations of specific valving and connection concepts.

No. 424 on Reader Service Card

PULL-AWAY COUPLING—A pull-away coupling for missiles and aircraft is the subject of a data sheet, Form 406, available from the **Weatherhead Co., Dept. S/A, Special Producets Div., Cleveland 8, Ohio.** The illustrated bulletin contains information on characcteristics, specifications, and operating facts.

No. 425 on Reader Service Card

CABLE ISOLATORS—A general data sheet, No. SV61A, covering cable isolators is available from **Aeroflex Corp., Laboratories Div., Dept. S/A, 34-06 Skillman Ave., L. I. City 1, N. Y.** It provides assembly diagrams and configurations, specification table, and other detailed technical information.

No. 426 on Reader Service Card

SLIP RINGS—Bulletin CON-14 discusses custom designed slip rings which have low electrical contact resistance and good electrical and thermal conductivity and is available from **Metals & Controls Inc., Dept. S/A, 34 Forest St., Attleboro, Mass.** The two-page bulletin describes types of slip rings available, dimensions, tolerances, and manufacture.

No. 427 on Reader Service Card

Ill-testing & support equipment

TEST FACILITIES—Test facilities, equipment and services available to industry and government are described in Bulletin LCT-611 prepared by the **Flight Propulsion Laboratory Dept., General Electric Co., Dept. S/A, Lynn, Mass.** Included are illustrated descriptions of the data recording center, and a discussion of staff and technical specialists.

No 428 on Reader Service Card

TESTING MACHINE—A four-page brochure describing the TM-1 autodynamic elevated temperature test machine for testing materials at extreme stresses, strains, and temperatures is available from **The Marquardt Corp., Dept. S/A, 16555 Saticoy St., Van Nuys, Calif.** It contains a description of the machine and its capabilities for conducting tensile, creep, stress-rupture, and compression tests at temperatures up to 5000 deg F, and programing of actual service condition load-temperature-time parameters.

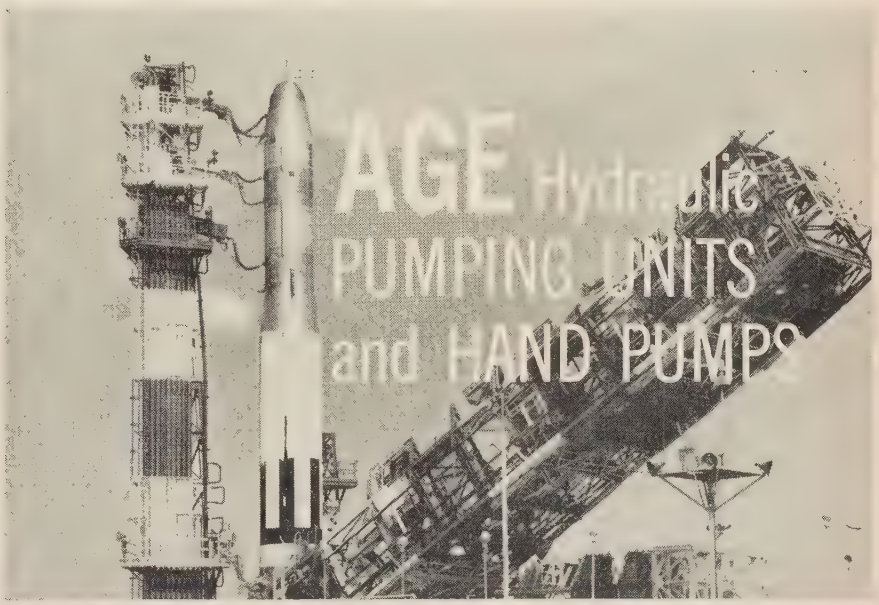
No. 429 on Reader Service Card

SHOCK TESTING—A 24-page technical bulletin discussing precision instruments for shock simulation testing of aerospace equipment is available from **Consolidated Vacuum Corp., Dept. S/A, Rochester 3, N. Y.** HYGE Bulletin 4-70 describes the company's line of shock testers, which can produce and repeat various shock waves such as half-sine, square, and sawtooth.

No. 450 on Reader Service Card

GROUND EQUIPMENT—A six-page brochure describing its capability in design, development, and manufacture of ground support equipment, training aids, and test equipment has been prepared by **Flight Support Div., Pacific Airmotive Corp., Dept. S/A, 11248 Playa Court, Culver City, Calif.** The brochure also illustrates specialized ground equipment which has been produced by the company.

No. 451 on Reader Service Card



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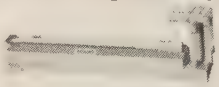
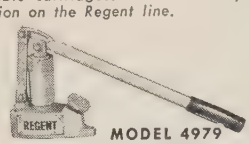
The industry's longest-lived, most reliable, quality units, Regents exceed all applicable military and commercial specs. A complete line—compatible to all volume and pressure requirements. Proved in aerospace ground equipment applications, including work stands, test facilities, trailers and dollies.

A FEW REPRESENTATIVE MODELS — Write for Engineering Data

MODEL 5256 PORTABLE PUMPING UNIT. Adaptable to most requirements, designed for hard usage and minimum maintenance. Ball-type release valves for long life. Wear and corrosion resistant. Check ball valves in quick, replaceable cartridges. *Write for complete information on the Regent line.*



MODEL 5336 PORTABLE PUMPING UNIT. Versatile, simple unit available with ½" and 1" diameter pistons, O-ring packings and Teflon back-up rings for long life. Any combination of pump size and reservoir capacity available, from 80 cu. in. to 480 cu. in. *There's a Regent Pumping Unit for every requirement.*



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5256	Single acting	1 1/16	.5	50	3,000
5020R	Single acting	½	.25	90	10,000
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5219	Single acting	½, 1 1/16, 1	.25, .50, 1.0	80, 190, 280, 410	10,000
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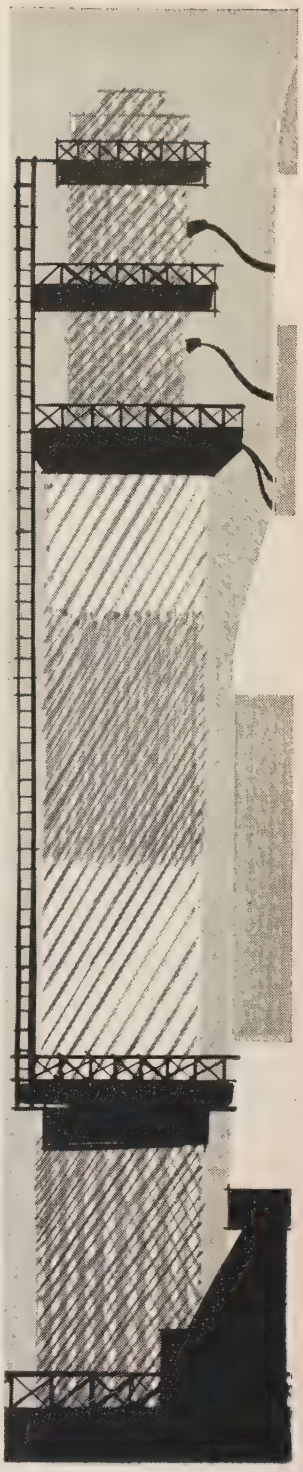

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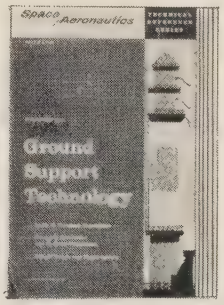

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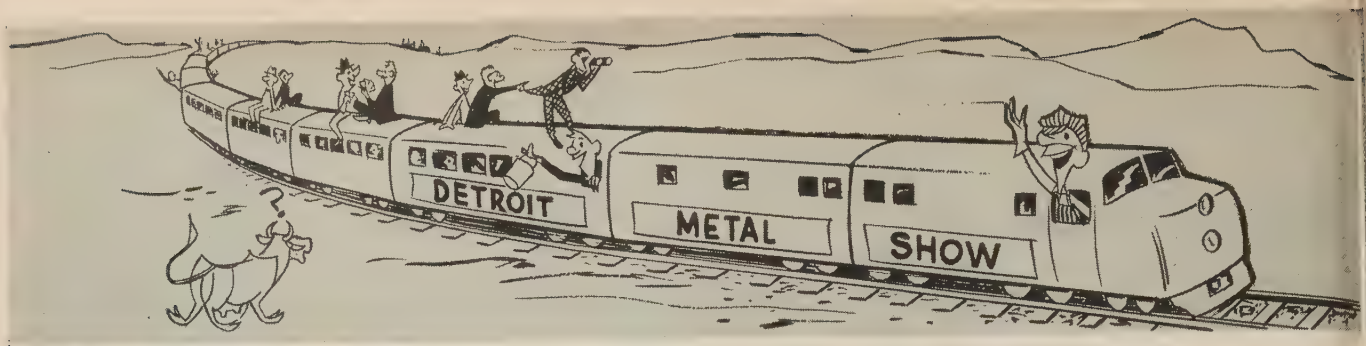

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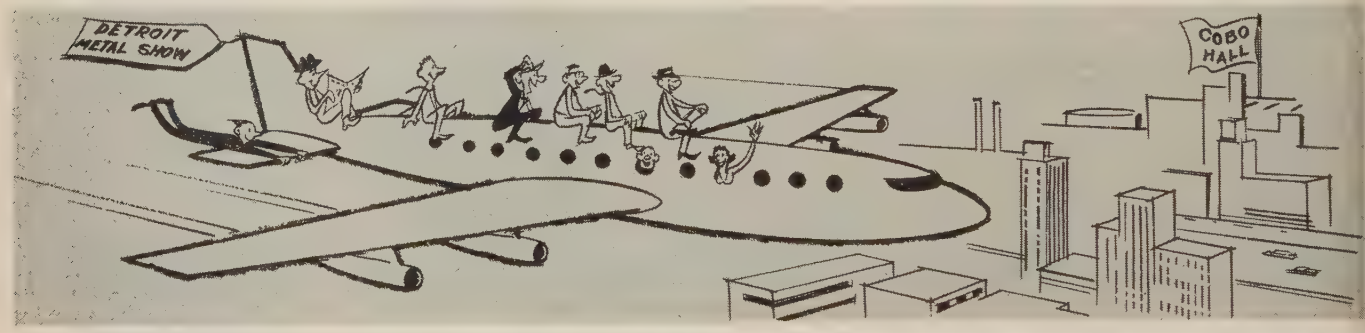

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reader's round table

The impact of the "technological explosion" on the aerospace industry is fairly well known. What isn't so well known is its effects on aerospace people. For example, what is the significance in terms of the technical knowledge and information requirements for engineers?

How to keep pace in the aerospace field

SPACE/AERONAUTICS asked a select group of top aerospace technical managers the following question:

"What do you think are the major requirements an engineer must meet in order to keep pace in the aerospace field?"

J. R. Clark, Vice President-General Manager, Astronautics Div., Chance Vought—A shift is taking place from the engineering, macroscopic point of view to the scientific, microscopic point of view. Macroscopic description of a system involves parameters such as length, volume, mass, velocity, pressure, temperature, etc. A microscopic description of the same system would involve molecular activity, type of molecules, their energy state, energy transition and the degree of equilibrium.

We are still interested in the macroscopic quantities of lift, drag, etc., but now we must also measure the hypersonic stream in terms of its chemical, molecular and atomic characteristics. We need an understanding of advanced physics, nuclear physics and quantum mechanics to define an airfoil or vehicle operating in this environment.

This is but one example of the trend toward the microscopic definition. Those who deal in propulsion or power generation will certainly be working with nuclear energy. Those in communications will be dealing with the physics of solid state transistors and developments beyond.

To keep pace with developments, an engineer must place more emphasis on the basic sciences. Basic physics and mechanics, chemistry and even biology are necessary to an appreciation and an awareness of problems and an awareness of design requirements. Nuclear physics will take its place alongside rocket engineering in the powerplant field, and materials are becoming increasingly important.

Courses offering aid in the conversion of aeronautical engineers to aerospace engineers include hypersonic aerodynamics, celestial mechanics, human factors, physics of metals, vector and analytical mechanics, thermal stress analysis, advanced metallurgy, bioastronautics, basic acoustics, and many others.

Although it is a tall order, the well-rounded engineer should have some knowledge of all these, as well as the fundamentals of detail design and design integration.

Dr. Ivan A. Getting, President, Aerospace Corp.—Successful development of missile and space systems is directly related to an increasing number of complex technologies.

The engineer must be familiar with many technologies in addition to having a thorough knowledge of his own special field. Working on a specific subsystem, he must recognize the interface problems in incorporating his subsystem into an overall system. It's his business to come up with the solutions to those problems.

He must be aware of the technological advances being made at such a phenomenal rate. Indeed, he must learn to anticipate them or his product will be outmoded before it is operational.

The engineer must be adaptable to advances in technology — seeking them out and learning to apply them effectively. He can never allow himself to consider his education and experience complete, but must continually press for the better way.

Erle Martin, Vice President for R&D, United Aircraft Corp.—The surest prediction one can make about the aerospace field today is that it is going to be different tomorrow.

In the last 15 years the industry has passed from piston-powered aircraft through supersonic jets and on to rocket-powered orbital vehicles. Just ahead lie nuclear and electrically propelled lunar and interplanetary vehicles. Success in these fields is not only crucial in war; they are a testing ground for the vitality of our democratic system.

To meet this challenge, we are now channeling over half of our R&D funds into aerospace sciences, and industry has enlarged its graduate engineering staff to close to 20 per cent of its total employment. The stage is now set, not just for another change, but for change itself.

In this environment, the young engineer now entering the field can expect to work his way up on one type of equipment, later manage a group working on another, and perhaps eventually run an organization providing something that has not yet been invented.

It is obvious that the information he needs cannot be pre-packaged in any formal education period. Instead, he must be given the tools with which to build his own education as his particular opportunities and responsibilities demand — of necessity, a continuous, lifetime process. This means that he must have a thorough grounding in the basic engineering sciences. At the same time, one senses today that it would be well to warn that the vast majority will still be doing engineering. While pure science has captured the popular imagination, the hard realities will require us to produce working devices, not just ideas.

Dr. W. L. Barrow, Vice President for R&D, Sperry Gyroscope Co.—I feel that it is now more than ever important that an engineer's training be founded on a broad scientific base such as mathematics and physics, including solid-state physics, so that the engineer may readily adapt to rapidly changing technologies. Even the specialist must lean on strong basic training to be able to incorporate and use new discoveries, and extend the specialty as required.

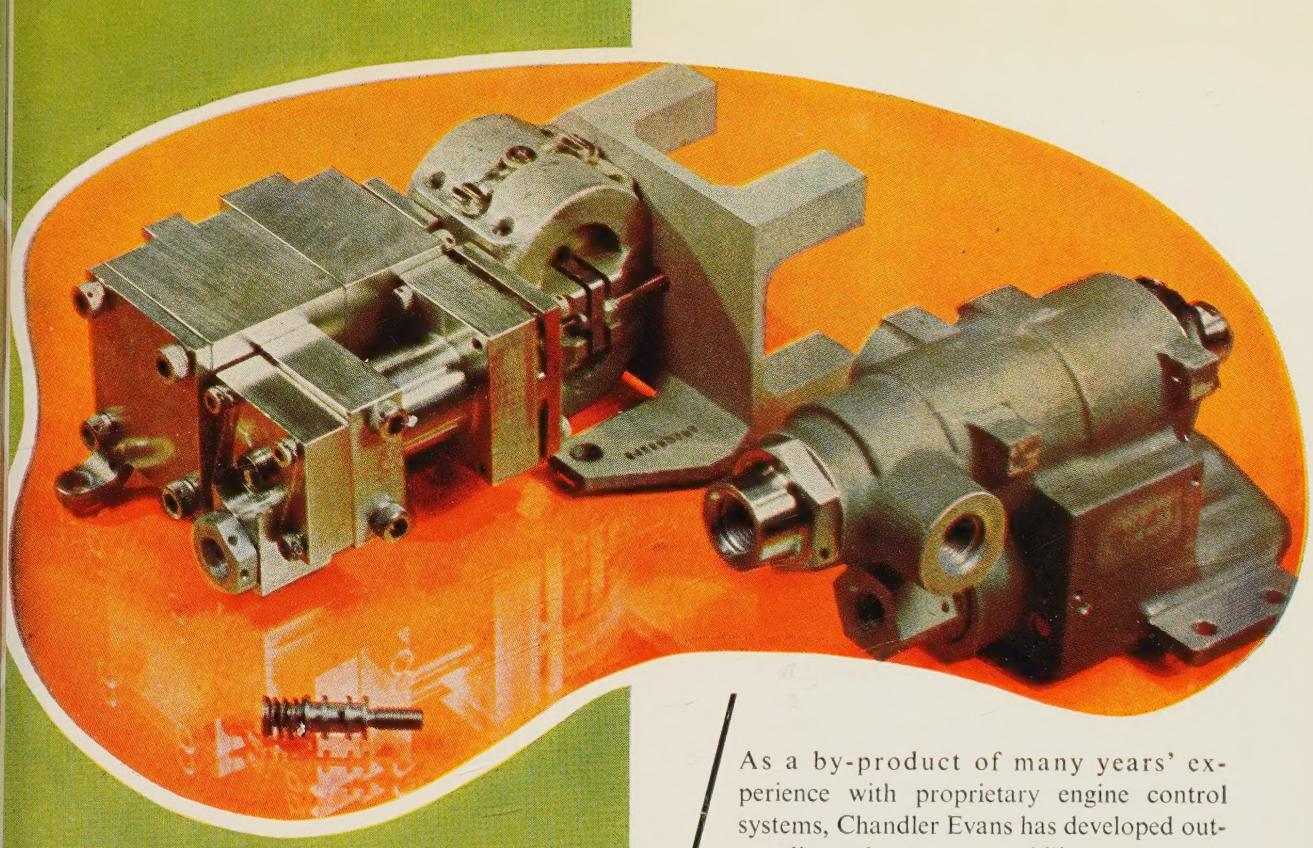
Classical physics — such as astronomy, electromagnetic theory, gaseous and solid mechanics — and modern particle and radiation physics are both important. Emphasis should be on basic disciplines rather than on the workaday world of solving contemporary engineering problems.

To be armed only with a cook book is not enough to cope with the exotic concoctions being asked for today.

Dr. Fritz Haber, Director, Marketing & Applications, Lycoming—The problem on which you are touching is, of course, an old one. It simply is the question, should one know much about a limited area or one should know little about a large area. In recent times, this problem became aggravated by the fact that there is so much more to know nowadays than before.

Another aspect of this problem which practically prohibits a general answer is the fact that an engineer today can be anything from a draftsman or technician to a president of a corporation. Depending on which end of this spectrum the engineer finds himself on, his requirements for knowledge and information are vastly different.

One thing in my mind is most important. The engineer must have a sound knowledge of the fundamentals. Since new basic knowledge is added almost daily, I believe that technical publications should emphasize articles in this area. This should be done in a manner which should be free of any encumbering details so that the principle comes to light clearly. Enough references should be included to provide further information on the subject if one wants it.



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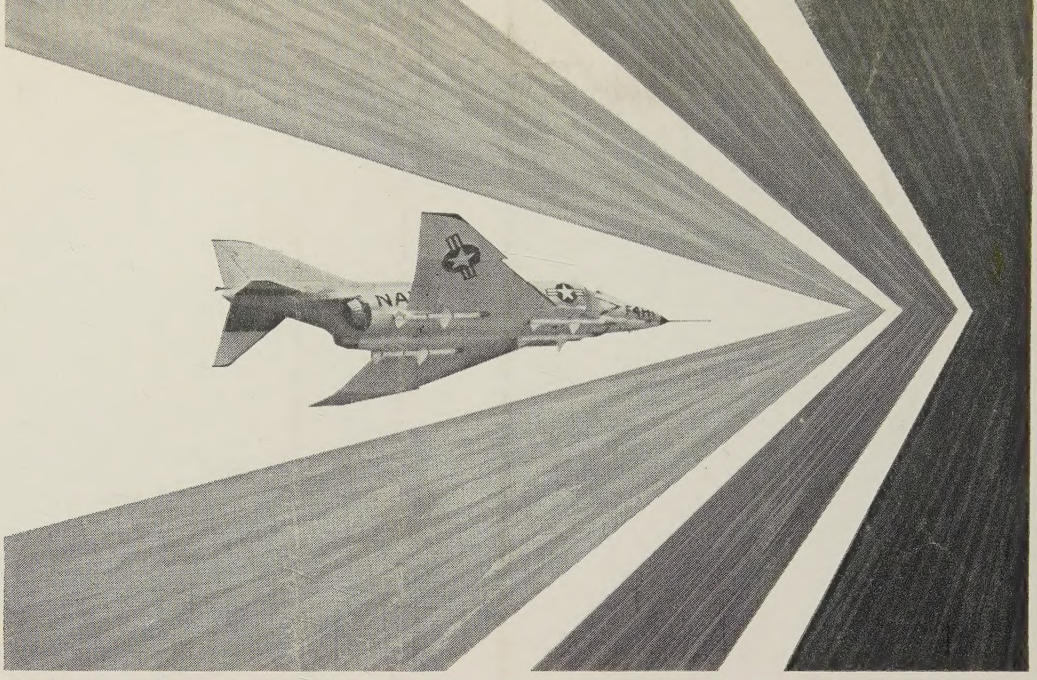

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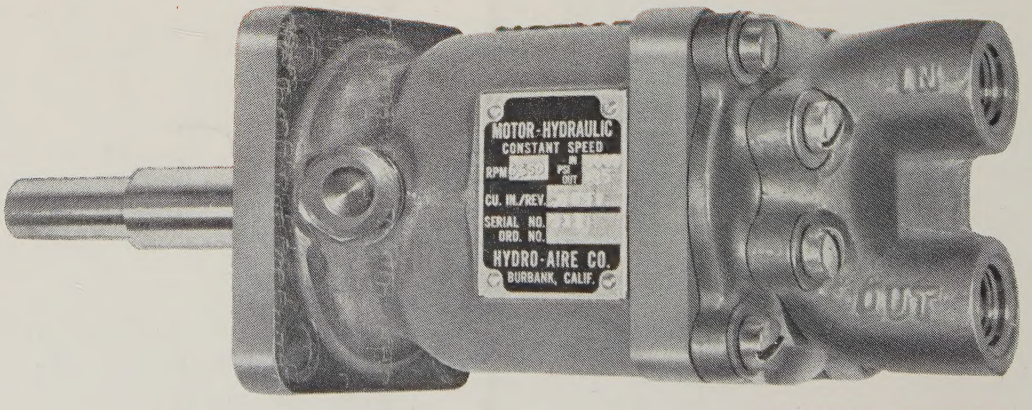

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